VOL. I. SERIES V. NO. 3.

THE MINERAL AND FOREST RESOURCES OF KENTUCKY

Published Quarterly by

THE
DEPARTMENT OF GEOLOGY AND FORESTRY

Of the

Commonwealth of Kentucky

Frankfort, Kentucky

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J. E. Barton, Commissioner
W. R. Jillson, State Geologist

October 1, 1919.

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Prospectus of Economic Papers Which Will Appear in Vol. 2, No. 1,

The Mineral and Forest Resources of Kentucky

Tentative Contents.

No. 1.—The Oil and Gas Geology of Johnson and Magoffin Counties, Kentucky. (Structural Maps).....W. R. Jillson

No. 2.—The Oil and Gas Geology of Grayson County, Kentucky. (Structural Maps).....W. R. Jillson

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No. 8.—An Oil and Gas Reconnoissance of Lyon County, Kentucky .....W. R. Jillson

Additional Short Papers May be Included.

Note:—The Mineral and Forest Resources of Kentucky—a new gratuitous serial publication—is issued in limited quarterly editions. One copy only is allowed upon request, to each individual or corporation. A file of those individuals and corporations who have requested all numbers in this series is maintained in the office of the Department of Geology and Forestry. Your name on this permanent file is the only method by which you may positively insure prompt delivery of subsequent numbers of this publication.

Edition History of the July, 1919, Number.

Mineral and Forest Resources of Kentucky,

Series V, Vol. 2, No. 1.

August 1, 1919—Entire edition, 1,500 copies, received from printer.
November 15, 1919—Entire edition, 1,500 copies, exhausted.

GEOLOGY OF BARREN COUNTY, KENTUCKY.

BY

CHARLES BUTTS.

Surveyed in Cooperation with the United States Geological Survey.

Introduction

A demand on the part of oil operators for information about the geology of Barren County led to the reconnaissance survey upon which this report is based. About six weeks were spent in the field examination. All parts of the county were visited, the formations outcropping were determined, and their boundaries approximately located. Owing to the lack of a topographic base map and to the brief time devoted to the survey, the locations of boundaries and areas of outcrop of the formations are less exact than would otherwise have been possible. The determinations of the lithologic character, sequence and thickness of the formations are, however, substantially correct.

Location.—Barren County is located in the south-central part of Kentucky, being bounded on the south and west by Allen and Warren counties which are the chief centers of oil interest in this part of the State.

Topography.—The general surface of Barren County is a dissected plateau about 800 feet above sea level. The elevation of Glasgow railroad station is 752 feet and of the railroad station at Glasgow Junction 591 feet. The elevation of the bridge across Barren River on the Louisville and Nashville pike is 533 feet, and the river level below is very near 500 feet above sea level. The northern half of the county, underlain by the St. Louis and Ste. Genevieve limestones, is relatively smooth and as a whole probably about 700 feet above sea level. A line of hills and ridges marks the southern outcrop of the Ste. Genevieve limestone. The northwestern corner of the county

is a plateau capped by the Cypress sandstone probably about 900 feet above sea level. This plateau is terminated on the southeast by a distinct escarpment which is a prominent feature visible from the Louisville & Nashville Railroad. Southeast of the escarpment stand several knobs and ridges which are outliers of the plateau rocks also capped by the Cypress sandstone. Pruitt Knob east of the railroad is the most eastern of these. These outliers have been separated from the main plateau by erosion. In the southern part of the county, while the higher ridges reach about the common altitude of 800 feet, the surface is more dissected by the streams tributary to Barren River. The slopes in this part of the county are in general, however, comparatively gentle. Only here and there are the main streams bordered by steep bluffs or by cliffs. Flood plains reaching an extreme width of one-half mile are sparsely distributed along the streams.

Elevations along the Glasgow branch of the Louisville & Nashville Railroad from mile posts 91 to 100, inclusive, based upon elevations run by the division officials of the Louisville & Nashville Railroad in 1918 are given below:

DATUM PLANE OF ELEVATION SEA LEVEL.

Elevation at Base of Rail.

Mile Post	Elevation
91	590.94
92	634.08
93	634.62
94	670.51
95	660.34
96	604.28
97	576.68
98	625.93
99	700.83
100	699.34

Elevation of the base of rail in front of the center line of the passenger station at Glasgow, 752.90 feet.

A considerable number of barometric determinations of elevations are scattered over the map. These are of course only approximate.

Drainage and Water.—The southern two-thirds of Barren County is drained by Barren River and its tributaries, of which Beaver, Skeggs, and Peters creeks are the principal. The northern third of the county is drained into Green River by streams only the headwaters of which are in the county. These streams and even most of their larger branches have some flow throughout the year. There are also many sink hole ponds scattered about the areas underlain by the St. Louis and Ste. Genevieve limestones. Adequate supplies of water for drilling can, in most localities, be had close at hand. Only on the ridges far from streams will water have to be pumped from a distant source.

Forests.—Barren County has been largely denuded of its forests. Most of the remaining timbered areas are along the deeper valleys and ravines, especially in the southern parts of the county. The northern half of the county, except the plateau escarpment in the northwest corner, is cleared and in cultivation. However, the lack of timber affects drilling operations but little, since all of the drilling is done by portable machines.

Soil.—Excepting the sandstone plateau in the northwestern part which has a sandy soil, the county has a soil derived from limestone. The red soils of the Ste. Genevieve and St. Louis limestones are normally fertile but have been more or less depleted by long cropping. The brownish loam from the limestone in the Warsaw foramtion makes some of the most fertile land of the county. The gray, cherty soil from the Fort Payne is in places fairly productive but in others rather sterile. There are wide flood plains in places along the streams covered with a naturally very fertile alluvial soil. Corn, hay, wheat and tobacco are the main crops.

Culture.—Barren County is one of the old settled counties of the State and has a population of 25,293. Glasgow, the county seat and terminus of the Glasgow railroad, had a population of 2,316 in 1910. It has good hotel and living accommodations. It is a great tobacco mart and the center of trade and distribution for several counties lying to the east and southeast. Cave

City, Glasgow Junction, and Hiseville are smaller towns, all having hotel and boarding house accommodations. Cave City is the point of departure for Mammoth Cave by automobile and Glasgow Junction is connected with the cave by the Mammoth Cave Railroad.

Excepting the old Louisville and Nashville pike, or Lincoln way, which has a Telford foundation, and the Tompkinsville pike, which is a metaled road, the roads of the county are all earth roads. These are much like the average country roads—fairly good in dry weather but bad in places in wet weather. There are also steep rocky declivities here and there which are difficult of passage for automobiles and heavy traffic. Many of the smaller bridges will not bear the weight of drilling outfits and require strengthening before crossing. In general probably the roads would be reasonably passable for drilling outfits at any season of the year.

Geology

The rocks outcropping in Barren County range from limestone of Silurian age below to limestone and sandstone of Mississippian (Chester) age above. The Silurian and Devonian limestones outcrop along Barren River in the southern part of the county and the Chester rocks outcrop on the plateau and its escarpment in the northern part of the county.

The lithologic character, divisions and subdivisions, sequence, thickness, and classification of these rocks are adequately set forth on the generalized columnar section and in its descriptive matter, while the areal distribution of the formations is shown on the geologic map, so that further detailed description seems unnecessary for this report, except in the case of the Silurian and Devonian formations which are the oil-bearing rocks of the region. In order to avoid repetition, the special description of the Silurian and Devonian rocks will be included in the section on the oil and gas-bearing rocks (see page 160.)

Structure.

The most important geologic feature of the county from the standpoint of the oil and gas production is the structure or "lay" of the rocks owing to the fact, amply

demonstrated, that, other things being equal, oil and gas accumulations in commercial quantities are far more likely to be located on and along the anticlines than elsewhere. In this part of Kentucky the general attitude of the strata is a very low dip or slope toward the northwest. This dip prevails from the axis of the Cincinnati anticline near Cumberland River on the east to the western Kentucky coal field on the west. This general northwest dip is, however, subject to local variations in rate and direction as indicated in the following table in which the elevations are, owing to several uncertain factors, only approximate. The principal uncertain factors are the thickness of the formations which varies from place to place and the surface elevations which are nearly all determined by barometer. Most of the structure determinations are based upon the elevation of the Chattanooga ("Black") shale which is, except on Barren River where the shale outcrops, determined from the surface elevation and the thickness of the formations between the surface and the top of the Chattanooga. The dip from the east side of the county to Glasgow is based upon the bottom of the Warsaw formation.

PLATE A.
Crest of the Temple Hill anticline on Skeggs Creek, 3,000 feet N. 30° E. of the locality described in A. Looking north.

Table Showing Amount and Average Dip of Strata Based Upon the Measured or Calculated Elevation Above Sea Level of the Top of the Chattanooga Shale and Bottom of the Warsaw Formation.

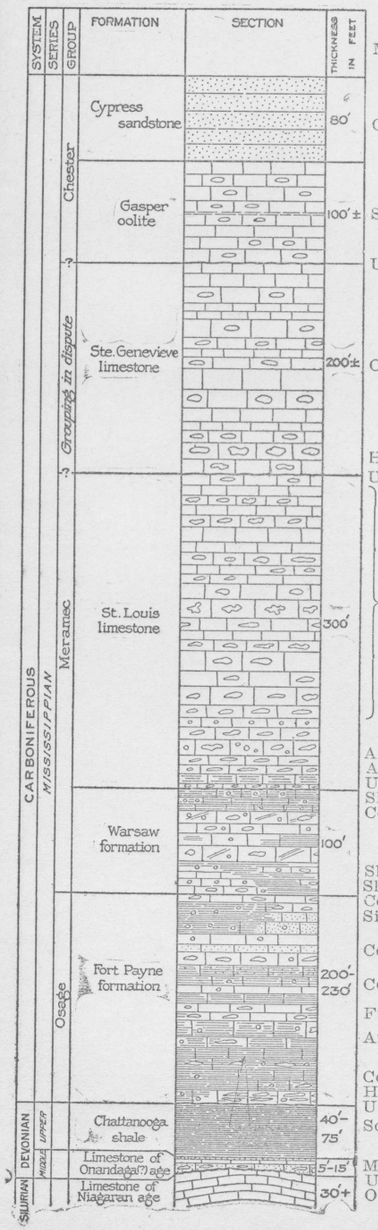
Locality	Elevation	Stratum	Elevation	Locality	Elevation	Stratum	Elevation	Distance in miles.	Amount of dip in feet.	Rate of dip per mile.
Barren River near mouth of Little Glover Creek	530	Top of Chattanooga shale	608	Barren River L. & N. Pike	500	Top of Chattanooga shale	504	7	104	15
Barren River near mouth of Little Glover Creek	530	Top of Chattanooga shale	608	Scarp northwest of Glasgow Junction*	900	Top of Chattanooga shale	100	24	708	29
Barren River near mouth of Little Glover Creek	530	Top of Chattanooga shale	608	Glasgow	752	Top of Chattanooga shale	422	16	186	11
Glasgow	752	Top of Chattanooga shale	422	Scarp northwest of Glasgow Junction	900	Top of Chattanooga shale	100	11	522	50
Glasgow	752	Top of Chattanooga shale	422	Hiseville	685	Top of Chattanooga shale	115	10	307	31
Glasgow	752	Top of Chattanooga shale	422	Bonayr	650	Top of Chattanooga shale	205	8	217	27
East side of county	750	Bottom of Warsaw formation	750	Glasgow	752	Bottom of Warsaw formation	650	10	100	10

*This calculation is based upon an assumed elevation of about 900 feet for the top of the escarpment and is subject to correction.

GENERALIZED COLUMNAR SECTION OF ROCKS IN BARREN COUNTY, KY.

Shows the rocks that would be penetrated by a hole 1100 feet deep on the top of Pruit Knob or high ground in north western corner of the county

Scale: 1 Inch = 166 Feet



Minor Notes.

Oil in Illinois.

Shale and clay near middle.

Unconformity.

Oil in Illinois (McClosky "sand").

Heavy highly fossiliferous chert.
Unconformity?

Lithostrotion basaltiforme (canadense).

Archeocidaris and fucoids abundant. Lithostrotion proliferum. First appearance.
Argillaceous limestone.
Unconformity?
Shale and argillaceous limestone.
Coarse crinoidal cross laminated limestone.

Shale, weathers soft and gray.
Shale, dark, firm. Limestone as above. Spirifer lateralis abundant.
Coarse crystalline limestone. Large crinoid stem plates abundant.
Siliceous limestone. Weathers porous and light and looks like sandstone. Very characteristic.

Coarsely crystalline, light gray, cherty limestone. Fossils. Agaricocrinus. Large Platycrinus stem plates.

Coarsely crystalline light gray limestone.

Ft. Payne about=Big Injun oil sand?

Argillaceous limestone, weathers shaly, greenish.

Coarse, light gray, pure, cherty, or argillaceous shaly.
Horizon of Beaver Creek oil "sand."
Unconformity.

Source of Kentucky oil from Irvine westward.

Main oil and gas rocks ("sand") coarse, fossiliferous limestone above (cap rock).
Unconformity.
Oil bearing in Allen County.

GENERAL CHARACTER OF FORMATIONS.

Thick-bedded, coarse, quartz sandstone. Only such in county. Caps Pruit Knob southwest of Cave City and other knobs and the high plateau in the northwestern corner of the county.

Thick-bedded, gray, predominantly oolitic limestone. Thin shale near middle representing the sample sandstone member of Breckinridge Co. Includes the equivalent of the Bowling Green oolitic building stone in the lower half. Separated from the underlying Ste. Genevieve by an unconformity due to the absence of the Bethel sandstone of Western Ky. Limestone of hign grade for lime cement, etc.

Thick-bedded, gray, generally oolitic limestone, lithologically indistinguishable from the Gasper oolite. Develops much chert on weathering. Many sink holes. Upper, thick-bedded part about 50 feet thick, probably represents the O'Hara limestone member of Western Kentucky, while the lower 150 feet is the Fredonia oolite member of Western Kentucky. Rosiclare sandstone member, between the O'Hara and Fredonia, not present in this county. The Ste. Genevieve is predominantly of high purity and excellent for lime, cement, fertilizer and other uses requiring high grade rock. Source of limestone used at the Kosmosdale Cement Works near Louisville. Quantity easily accessible unlimited. In Illinois the Ste. Genevieve includes the McClosky oil "sand." Mammoth Cave is largely excavated in the Ste. Genevieve.

Generally rather thick-bedded, predominantly dark gray, finely crystalline limestone. Contains, however, layers of gray finely crystalline fairly pure limestone and layers of gray, earthy textured, or argillaceous limestone making a considerable proportion of the whole. Almost destitute of oolitic limestone. One black oolitic layer seen. Ste. Genevieve and Gasper oolites light gray. Developes much chert on weathering. Surface underlain by St. Louis marked by many sink holes. Lower levels of Mammoth Cave in St. Louis. Characterized throughout by two species of the coral Lithostrotion, L. basaltiforme, massive heads of 5 or 6 sided coralites, and L. proliferum, rather open heads of cylindrical coralites. They occur in no other formation. L. proliferum comes in 15 to 20 feet above the bottom in layers also full of Archeocidaris plates and spines and of fucoids. Same also in Overton Co., Tenn. St. Louis limestone should make good road metal and possibly fertilizer but probably not pure enough for lime or cement. St. Louis meagerly exposed. Best shown on Edmonton road 1½ miles east of Beaver Creek and on Beaver Creek near county line.

Mainly coarse, crinoidal, bluish, thick-bedded limestone, but contains shale and argillaceaus limestone, weathering shaly; varies from one kind to other in short distances both vertically and horizontally. Cross lamination prevalent and characteristic in crinoidal layers. Nothing like it in other formations. Highly fossiliferous. Myraids of spirifer lateralis and sp. Washingtonensis in bottom layers which also contain Productus magnus. These not in crinoidal layers of Fort Payne immediately below. Many geodes.

Mainly an argillaceous limestone weathering to shale. Cherty and geodiferous. Locally shale in upper and lower parts. Includes beds of pure, coarsely crystalline, light gray limestone at top, 40 ft. below top and about 80 ft. below top. Some cherty or flinty layers making very hard drilling. Upper half includes layers of highly siliceous limestone which become porous and light on leaching of the lime by weathering. This rock, looking like sandstone, is highly characteristic of the formation. The lower 50 feet of rock tends to a greenish color. The shaly facies is usually dark or slate colored. Purer limestone layers highly fossiliferous. Crinoids, corals, and brachiopods most common. Layers just below Warsaw carry invariably many crinoid stem plates up to 3-4 inch in diameter also ornamented calyx plates. None such in Warsaw. Limestone bed 30 to 40 feet below top has Agaricocrinus americanus, elliptical stem plates of Platycrinus over 1 inch long, and several species of brachiopods.

Black fissile shale. Lower 10 feet with thin, calcareous sandstone layers and laminae in soft fissile shale with Schizobolus truncatus (Genesee shale brachiopod). Upper part carries Lingula melie and Orbiculoidea newberryi. (Sunbury shale fossils). Shale carries about 10 gal. oil per ton.

Massive, coarse, light gray, limestone below, locally with sandy lenticles, locally fine grained, blue, locally absent. Oil bearing bed ("sand"). Exposed on Barren river at mouth of Little Glover Creek and below.

Thick-bedded, light gray, to yellowish, fine-grained or chalky textured limestone. Probably highly magnesian or dolomite. Exposed on Barren river at mouth of Little Glover Creek and below.

It is clearly brought out in this table that the strata are very nearly horizontal on the average in the southeast part of the county, but are more steeply inclined from the vicinity of Glasgow northeastward, northwestward, and westward. An examination of the geologic map reveals a further local steepening of the dip to the northwest of Glasgow in the comparative narrowness of the outcrop of the St. Louis limestone. On the Cave City road via Pruitt Knob, the outcrop of the St. Louis is barely 2 miles wide. The difference in the elevation above sea of the point on the road where the bottom outcrops and the elevation of the point 2 miles northwest where the top outcrops is about 100 feet and as the thickness of the St. Louis is about 300 feet, its bottom beneath the point of outcrop of its top must be 200 feet lower than its bottom 2 miles to the southeast. Hence there is a northwest dip of 200 feet in 2 miles. It is suggested that this comparatively steep northwest dip along this narrow belt of St. Louis may be connected with the accumulation of oil in the Oil City pool which lies immediately to the south. The structure is apparently a terrace and it is not improbable that richer accumulations of oil exist farther to the northwest than developments have yet revealed. This area of steep dip is worthy of testing.

In contrast to the belt of steep dip just described the much wider area occupied by the outcrop of the Ste. Genevieve limestone and Gasper oolite, which together have about the thickness of the St. Louis, indicates clearly a flattening of the strata and possibly a broad shallow syncline, the axis of which lies near Pruitt Knob and extends into the narrow end of the Ste. Genevieve area northwest of Hiseville where the relations of the Ste. Genevieve and St. Louis areas may indicate a syncline. However, this relation is in part due to topography, the Ste. Genevieve area being higher than that occupied by the St. Louis.

Minor Details of Structure

Besides the larger structural features already described, a number of small anticlines are known. In places there is a southeast dip, and, in others, there is a north-

west dip greater than the normal. A southeast dip necessarily implies an anticline whether its axis can be located or not and a northwest dip stronger than the normal may indicate an anticline or only a monocline with a flattening to the southeast making a terrace structure. The known minor structures are named and described beginning on the west and proceeding eastward.

Skeggs Creek (monocline).—On Skeggs Creek, a short distance above where it is joined by Beaver Creek, the rocks dip northwestward in an undulating manner for several hundred feet, the net dip being about 5°. The strike is about N. 50° E. At the most southeastern exposure in the bluff of the creek the strata appeared to be nearly flat but there was no reverse (southeast) dip at that point.

Pageville (monocline).—The Pageville monocline is a structure parallel to the Skeggs Creek monocline, the strike being N. 50° E. and the average dip being about 5° N. W., except at the most northwestern point observed, on Barren River a short distance below the mouth of Peters Creek, where the strata are wavy and of low average northwest dip. The total width of this structure appears to be about one-fourth mile. Probably the strata are undulating for the observed dip could not persist for that width without bringing the Chattanooga shale to outcrop in the bed of Peters Creek at the mill at the bridge.

Haywood Anticline.—At Haywood the bottom of the Warsaw is about 710 feet and about 1 mile east-northeast the bottom is 680 feet above sea level. On the outcrop south of Bruce the bottom is about 610 feet above sea level or 100 feet lower than at Haywood. and on the bluff of Skeggs Creek about 1 mile southeast of Mathews mill the bottom of the Warsaw is about 80 feet lower than at Haywood. There is thus a distinct southward dip from Haywood and a low northward dip as well. At the Oscamp locality 1½ miles east of Haywood is a low anticline and at the road crossing of Boyds Creek, a short distance south, is a northward dip of about 2° with a strike apparently of N. 70° E. Between the two points is a

shallow syncline. Except for 200 feet or so the strata are not exposed south of the road crossing. A mile and a half northwest of Haywood where the road crosses Gas Hollow Creek, a dip of 2° south was measured, the strike being N. 60° W. The bottom of the Warsaw is 30 feet higher north of the creek than south of it. A possible interpretation of these observations is that there is a curving axis extending from the Oscamp locality through Haywood and northwestward from that place. Another possible interpretation is that the Skeggs Creek structure is anticlinal and that the axis strikes northeastward through Haywood. If the latter interpretation should be the correct one, both the structure at Oscamp and that northwest of Haywood would be separate anticlines, striking parallel to the Skeggs Creek (monocline) or the Haywood anticline. It would require much detailed work to satisfactorily determine all the important structural facts indicated by the scattered observations in that locality. There is surely good oil and gas structure there and thorough testing is warranted. Owing to the uncertainties set forth above no axis has been drawn.

Elbow Spring Anticline.—Just northwest of Elbow Spring on the Burkesville pike a southeast dip of about 3° prevails for a width of about one-fourth mile and along Fallen Timber Creek about one-half mile above its mouth a like dip exists for the space of several hundred feet. Judging from the strike at both places the observed dip is on the southeast limb of the same anticline, the axis of which is probably near the position as drawn on the map. The existence of an anticline here is inferred from the southeast dip just described and the general structure of the county, although no perceptible northwest dip was observed, the dip on the northwest limb being probably only a few feet to the mile. The southeast limb of this structure seems of sufficient dimensions, breath and height, etc., to affect favorably the accumulation of oil and gas. Testing along or somewhat to the southeast of the position of the axial line would be justified.

KINO ANTICLINE.—The Kino anticline is one of the most definite observed in the county. Its axis pitches steeply to the southwest 2 miles southwest of Kino where the circular strike of the beds with dip to southwest and west are fully revealed in the little branch crossing the road at that point. The northwest limb is not exposed. Just east of Kino the southeast dip of about 5° is clearly shown by the outcropping edges of limestone layers in the Warsaw formation. The structure probably dies out southwest of the point exposed in the little branch. Its northeastward extension is unknown beyond Kino, although it probably extends for considerable distance in that direction.

TEMPLE HILL ANTICLINE.—A low but distinct anticline with visible southeast and northwest dips lies three-fourths of a mile or so southeast of Temple Hill. The arch is fully exposed at the mouth of the branch of Skeggs Creek joining the creek just above the bridge 1 mile south of Temple Hill. The arch is so conspicuous here that it has received the name "Devil's Nose." The arch is also exposed 3,000 feet N. 30° E. of this point on the north bank of Skeggs Creek. It is nearly symmetrical at both places with maximum dips of about 5° and is probably

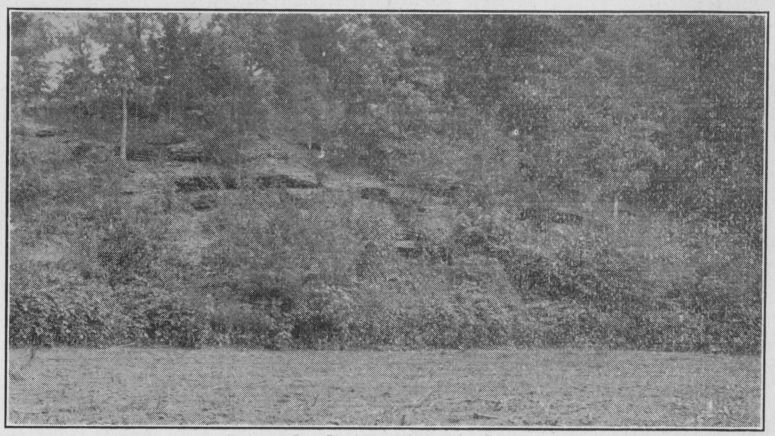


PLATE B.

Crest of the Temple Hill Anticline just east of the Tompkinsville Pike bridge across Skeggs Creek, one mile north of Temple Hill.

about 800 feet in width. The Kino and Temple Hill anticlines are ideal structures for oil accumulation.

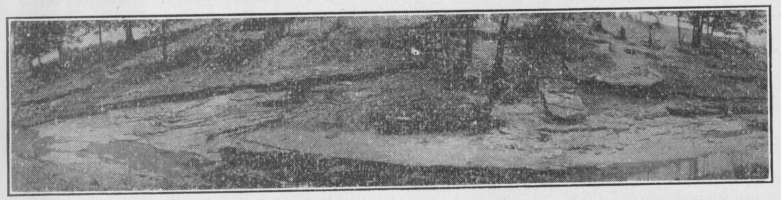


PLATE C.

View of the Kino Anticline looking northeast. Brook just southeast of road two miles southwest of Kino. The dips here suggest the southwest end of a pitching anticline.

LITTLE GLOVER CREEK ANTICLINE.—At the mouth of Little Glover Creek in the southern part of the county the top of the Silurian limestone is at water level in Barren River. About three-fourths of a mile down the river the top of the Silurian is 30 feet above river level, so that after allowing 5 feet for the fall of the river the northwest rise of the Silurian beds is 25 feet. It is not known whether this point is the summit of the anticline but it is probably near it, for three-fourths of a mile farther down stream, in the bend of the river, the Silurian has descended about to water level. This anticline is probably the northeastern extension of the belt of low domes in the vicinity of Petroleum and Adolphus in Allen County, described and mapped by Mather in United States Geological Survey Bulletin 688. The line of those structures prolonged to the northeast would intersect Barren River near the point at which the Little Glover Creek axis is located.

In connection with this anticline is a demonstration of the suspected fact that the surface and underground structure is not everywhere parallel. At the mouth of Little Glover Creek the Silurian limestone is immediately overlain by 9 feet of limestone, the lower 7 feet of which is sandy and weathers cavernous. This is the Devonian oil-bearing bed. On the crest of the anticline, however, this part of the Devonian is absent having thinned out, as can be observed in the intervening distance. Hence, while the top of the Silurian bed rises 25 feet, the

top of the Chattanooga shale rises only 16 feet between the mouth of Little Glover Creek and the crest of the anticline. These circumstances are illustrated by sections in Fig. 1 in connection with the discussion of the oil-bearing rocks.

In this connection also reference may appropriately be made to the large gas wells in the vicinity of Hiseville. The occurrence of areally extensive and quantitatively great accumulations of gas is strongly suggestive of pronounced anticlinal structure. If any such anticline exists along the line of the gas wells, however, it has not been detected nor is any such suggested by what observations the writer has been able to make. Indeed the uniformity in level of the outliers of Ste. Genevieve oolite on the knobs southeast of Hiseville seems to be evidence against the existence of an anticline. However, a hidden anticline is still possible.

It is highly probable that by traversing all the streams of the county, especially those of the southern half, other anticlines may be found. It is also probable that by precise determinations of the elevation of many points on the contacts of the different formations additional favorable structures would be disclosed. The thorough application of this last mentioned method would be a very laborious and expensive procedure and would require in advance a topographic survey and map with a close net of level lines to check elevations determined by barometer and hand-level or to serve as starting points for spirit level or vertical angle and stadia determinations. Excepting the Chattanooga shale there is no key bed or beds that can be used in determination of structure from surface outcrop. Owing to the small area in which it outcrops the Chattanooga would be of but slight service in elucidation of the structure of the entire county in advance of drilling. However, after drilling, and with accurate measurements to the top of the Chattanooga in the wells it will be of the utmost value for structure determinations. Of the contacts, that between the Fort Payne and Warsaw, which can be very precisely determined in most parts of the county where it outcrops, would be the most serviceable. The contact of the Warsaw and St. Louis can not be so closely determined but,

in most places, probably can be located within contour interval of 20 feet. The same holds true of the St. Louis-Ste. Genevieve contact. The contact between the Gasper oolite and Cypress sandstone can be precisely determined but, owing to the small extent of its outcrop, could not be used in a very large area.

At best, there are large parts of the county, such, for example, as the areas of St. Louis limestone northeast and northwest of Glasgow and the large area of Ste. Genevieve limestone and Gasper oolite in the northern part of the county, in which the discovery of minor structures from surface observations is practically impossible. The difficulty with these areas is the generally flat surface, the lack of extensive exposures, and the lack of distinctive beds within the limestones.

Relation of Oil Accumulation to Structure

In this region the relation of oil occurrence to structure is known in a few cases only. The Oscamp pool on Boyds Creek is clearly associated with a fairly strong dip and probable anticlinal structure. Indeed the arch of a very low anticline is exposed in the bed of the creek directly opposite the wells on the Oskamp property just west of the creek. As already mentioned in the description of the Haywood anticline (page 154), the gas wells in Gas Hollow, 2 miles west-northwest of Haywood, are associated with an anticline or a reverse southwest dip which implies an axis to the north. The wells along Boyds Creek south of the Oskamp and Hoffman wells on the north seem to be on the south slope of the Haywood anticline. The Chattanooga is reported 50 feet below creek level in the Oskamp locality and 38 feet at the mouth of Boyds Creek in the south, and, as the fall of the creek is considerably greater than the difference of 12 feet in depth of the shale, the shale must dip to the south in conformity with the base of the Warsaw. So far as a superficial examination of the surface exposures show, the strata are nearly horizontal in the Winlock-Steffy pool. However, some suggestion of very low dip was observed in places, and the depth to the Chattanooga in a few of the wells indicates a low undulation in the strata perhaps

of the nature of low domes and corresponding depressions or dimples. For example, the height above sea of the top of the shale in Winlock No. 4 well seems to be slightly greater than in the Richard Steffy No. 1 well of the Panhandle Oil Co., about one-half mile to the west-southwest and in a well about three-fourths of a mile south of the said Steffy well the top of the shale is 50 feet higher than it is in the Steffy. While the dip between the well to the south and the Steffy is normal in direction for the region, its rate is much greater than the normal. The facts stated afford only a glimpse of the low structures that probably exist in the region and that in many cases could be precisely determined by detailed instrumental work and by utilizing the data obtainable from the well logs. While structure determinations by the last named means would depend largely upon developments made independently of a knowledge of structure, they would greatly aid subsequent operations by affording a knowledge of the location and trend of the structural axes. The Moulder pool in Warren County a mile or so west of the southwest corner of Barren County is distinctly anticlinal, the developed part being on the southeast limb. The crest of the anticline has not yet been determined. The gas wells in the vicinity of Hiseville as already discussed (page 158), suggest an anticline, the existence of which has not been demonstrated.

The Oil and Gas-Bearing Rocks

So far as known to the writer, the main reservoirs of oil in Barren County are within a few feet below the bottom of the Chattanooga ("Black") shale supposed to be in a porous, sandy limestone of Devonian and probably of Onondaga ("Corniferous") age. There are a few occurrences at greater distances below the Chattanooga shale that are referable to the Silurian horizons of Allen County as described in United States Geological Survey Bulletin 688 on Allen County. The only other oil horizon reported is in the Fort Payne formation and seemingly near the middle of that formation. Here amber oil usually in small quantity is common. The Devonian is likewise the reservoir of the gas in the wells

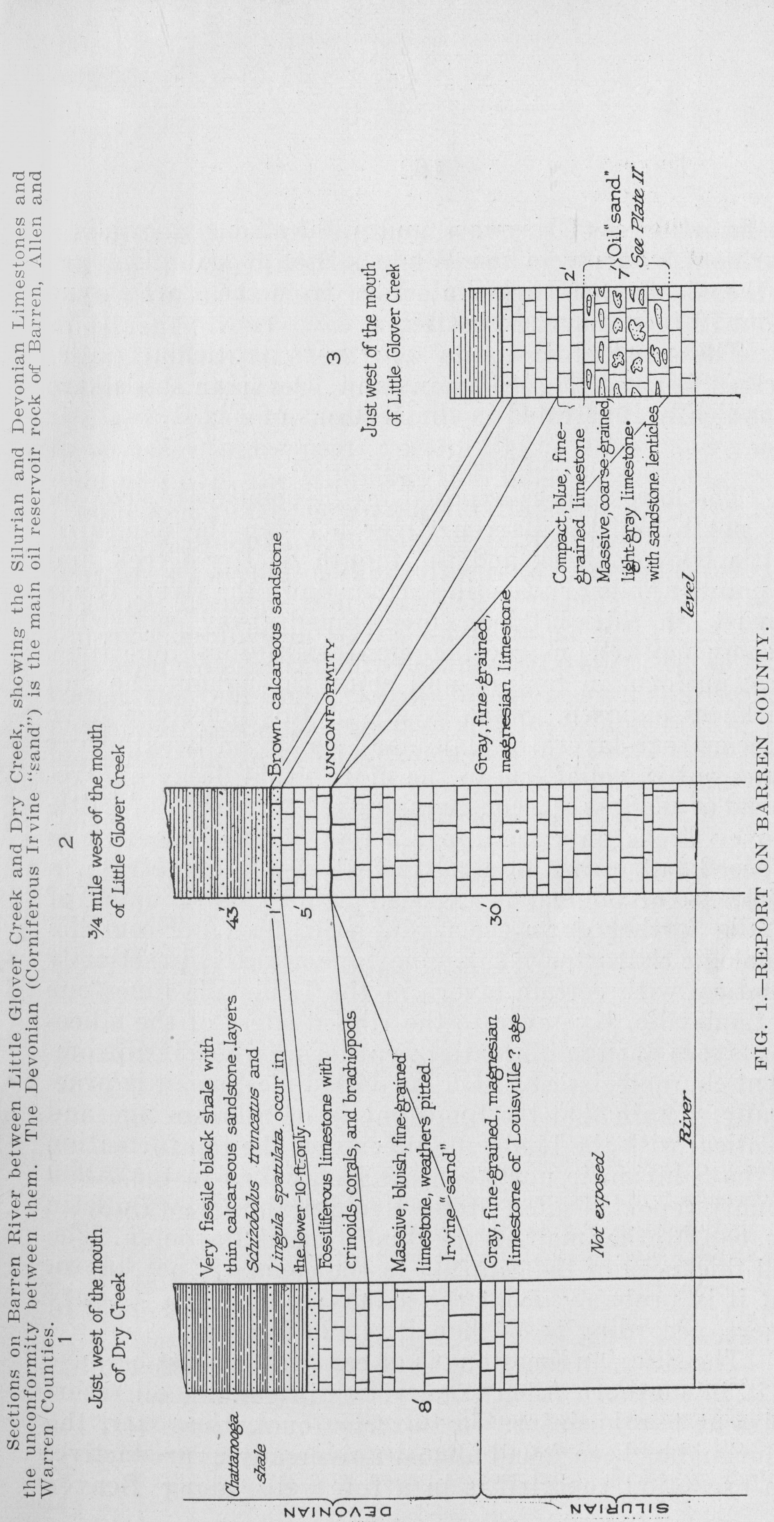


FIG. 1.—REPORT ON BARREN COUNTY.

No. 1.—Just west of mouth of Dry Creek.
No. 2.—¾ mile west of the mouth of Little Glover Creek.
No. 3.—Just west of the mouth of the Little Glover Creek.
Scale:—1 inch—16 feet.

west-northwest of Haywood and in the strong gas well on Furlong property in the Winlock-Steffy pool. The gas in the vicinity of Hiseville comes from the Fort Payne about 70 feet above the bottom.

The productive strata are more particularly described below. The Silurian and Devonian beds are graphically illustrated in the sections of Fig. 1.

Silurian Limestone

The lowest rocks exposed in the county are seen on the north bluff of Barren River between the mouth of Little Glover Creek and the mouth of Dry Creek and at points a mile or two still farther down the river. These consist of thick-bedded, fine-grained, gray somewhat creamy mottled, magnesian, nonfossiliferous limestone, very uniform in texture and color throughout the full thickness exposed. Some layers of this limestone have siliceous sub-layers or laminae which on weathering stand out in relief due to the more rapid decay and removal of the less siliceous laminae. At the mouth of Little Glover Creek only the upper 2 feet of this limestone is exposed but owing to a northwest rise in the strata, a thickness of 30 feet is exposed about three-fourths of a mile farther down the river. (See fig 1.) From the lithologic character of this limestone, which is practically identical with certain layers in the Louisville limestone at Louisville, Ky., even to the ribbed edges of the siliceous layers due to differential weathering which is a prominent characteristic of the Louisville limestone, it is practically certain that the limestone is of Silurian age and identical with the Louisville limestone, the top formation of the Silurian in north-central Kentucky. In the Allen County report, United States Geological Survey Bulletin No. 688, Mather mapped this limestone as Devonian. The full thickness of the Silurian in the county is not known but it is probably about the same as in Allen County where, according to Mather, it is 125 feet.

The Silurian limestone is of especial interest because in it, in southern Allen County, are productive oil reservoirs at two horizons. In Barren County, however, the Silurian has been found almost universally unproductive. An exception reported is in a few wells along Beaver

Creek northwest of Glasgow where a little green oil occurs at the depth of 90 feet below the bottom of the Chattanooga shale, and on the Winlock property 5 miles west of Glasgow where two wells show enough oil at 60 feet below the Chattanooga to be considered as possible small producers from that horizon. Wells recently drilled on the Lewis property near Mathews Mill and on the Button farm a few miles northwest of Lucas have good showings of oil in the Silurian. Drillings from some wells from about 90 feet below the Chattanooga contain a considerable proportion of quartz sand and it is probable that the oil occurs in sandy layers at varying depths, as in Allen County. Southern Allen County seems to be the only locality in which oil in commercial quantities had been demonstrated to occur in Silurian rocks in Kentucky, the only other known occurrences being apparently that of the Colmar field in Illinois and that of the so-called Clinton sand of Ohio.

Devonian Limestone

Overlying the Silurian limestone along Barren River is about 15 feet of limestone of undoubted Devonian age. There are at best three and perhaps four distinct members of this limestone, as shown in the section below.

SECTION OF DEVONIAN LIMESTONE ON BARREN RIVER

(See Map.)

	Feet
CHATTANOOGA SHALE:	
1. Shale, black, thin calcareous sandstone layers in the lower 10 feet, the associated shale carrying the characteristic Genesee shale fossils **Schizobolus truncatus** and **Lingula spatulata**	43
DEVONIAN LIMESTONE:	
2. Sandy limestone or calcareous sandstone chocolate brown, medium textured. Cemented to the underlying limestone. Hamilton age?	1
3. Limestone, gray, coarsely crystalline, highly fossiliferous, crinoid stem plates abundant, also corals, Bryozoa, and brachiopods. Layers about 1 foot thick. Some of the	

crinoid columns like those of the Beechwood ("Encrinal") limestone of the Louisville region, of Hamilton age. "Cap rock" of oil operators..... 5

4. Limestone, bluish gray, fine-grained, compact, rather distinct in the section at the mouth of Little Glover Creek Sec. 3, fig 1..... 2

5. Limestone, massive, weathers pitted and cavernous, variable in color and texture, sparingly fossiliferous at mouth of Little Glover Creek, Sec. 3, fig. 1, coarsely crystalline, very light gray, and full of small sandy lenticles weathering to sandstone. At mouth of Dry Creek, bluish gray, fine grained.* Oil-bearing stratum of the Devonian; probably of Onondaga (Corniferous) age. 7-9

The Devonian limestone is well illustrated in the photographs of Plate F

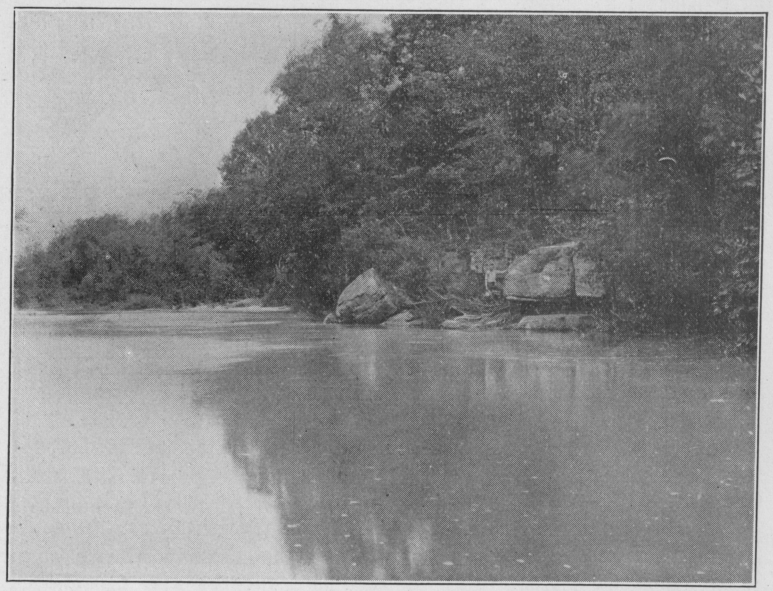


PLATE D.
Contact of Silurian and Devonian limestones. The massive bed is the Devonian. Barren River at mouth of Little Glover Creek. Looking west.

The sequence and thickness of these members of the Devonian limestone seem to be persistent throughout Barren County. On the Moulder property in the

*This bed at mouth of Dry Creek may be Silurian.

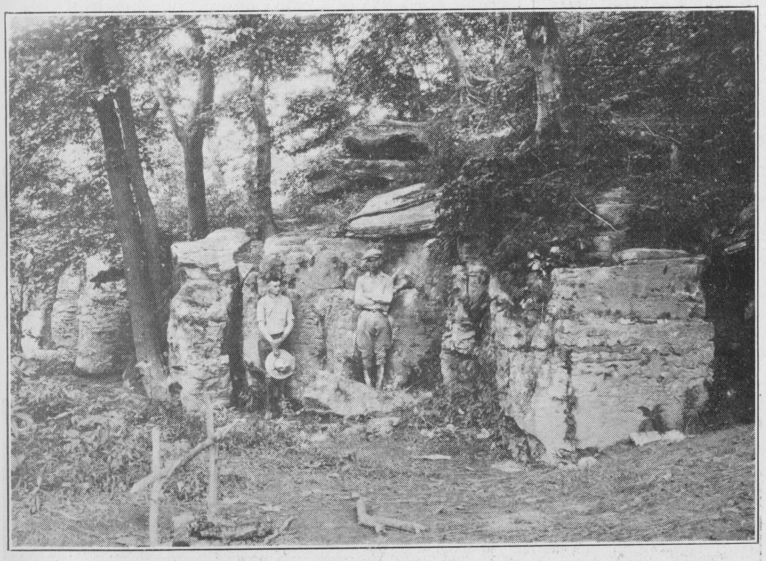


PLATE E.
Nearer view of a part of E showing the sandstone lenticles and pitted surface of the oil rock due to weathering.

southeastern corner of Warren County, the drillings from immediately above the "cap rock" contain chips of brown, calcareous sandstone practically identical in color and texture with specimens of the sandstone collected on Barren River at the mouth of Little Glover Creek. On the Moulder property also the "cap rock" No. 3 of the above section, p. 163 is 5 feet thick, highly fossiliferous, and coarsely crystalline. Fragments blown from the gas well on the Furlong property 4 miles southwest of Glasgow are of the same character. Both at the Moulder and Furlong localties the color of this rock is brownish or yellowish, somewhat resembling the usual appearance of the zinc mineral sphalerite, zinc sulphide. In most wells the cap rock is reported about 5 feet thick, but in some wells only 3 feet is reported, while in others 7 feet is the thickness. The greater thickness may be due to the presence of the 2 feet of compact blue limestone, No. 4 of the section, page 164, and of the section at the mouth of Little Glover Creek (Fig. 1, No. 3.)

Immediately beneath the "cap rock" gas or oil is encountered. If gas appears first the oil comes in about a

foot lower. The oil rock ("sand") is reported to be sandy limestone and usually about 7 feet thick. The usual distance from the bottom of the Chattanooga shale to the bottom of the oil rock being generally given at about 15 feet, it is safe to say that everywhere in southern Barren County the Devonian oil rock will be in the first 20 feet below the bottom of the Chattanooga shale. Conversely it is assumed that any occurrence of oil within 20 feet below the Chattanooga is from Devonian limestone, but that assumption is not necessarily true for the Devonian might be absent and the oil occur in the top of the Silurian.

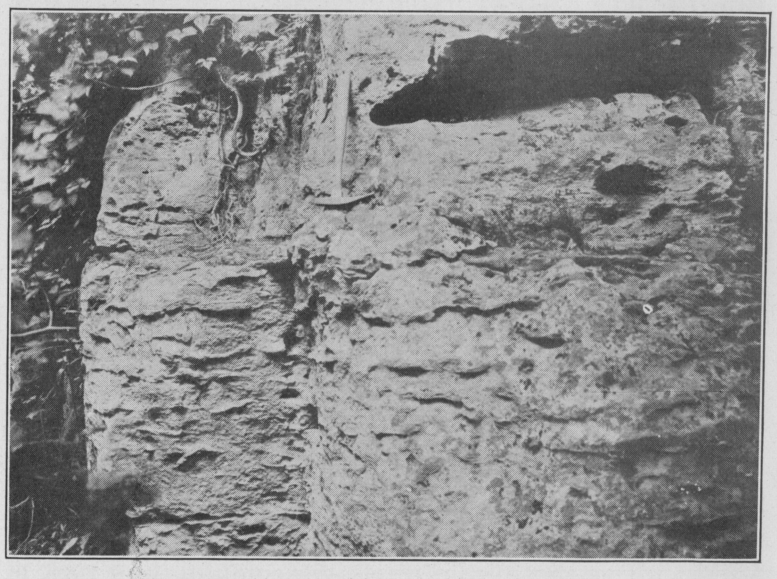


PLATE F. DEVONIAN LIMESTONE.

Massive bed at bottom nine feet thick is the oil-bearing stratum of Barren County and the principal oil rock of Allen and Warren counties. The lenticles of sandstone in relief show in places. The bedded limestone above five feet thick is the highly fossiliferous "cap rock" of the region. The Chattanooga shale is just above the top layer of limestone. View on Barren River at mouth of Little Glover Creek, looking west.

Chattanooga Shale

The Chattanooga shale has two phases in the region —an upper, entirely shale phase, and a lower, comprising the bottom 10 feet, shale and sandstone, phase. The upper phase is a densely black fissile clay shale with

Lingula melie, Orbiculoidea newberryi, and probably *Barroisella.* The lower phase consists of very soft, very finely fissile, and very black shale in which is interbedded calcareous sandstone layers from one-sixteenth of an inch to 1 foot thick. This part of the Chattanooga carries the characteristic Genesee shale fossils *Schizobolus truncatus* and *Lingula spatulata* and is with good reason regarded as of the age of the Genesee shale of western New York, which is also densely black. The thickness of the Chattanooga varies from 40 feet on Barren River to 70 feet at Bonayr and probably greater farther northwest. The Chattanooga is of great interest and importance as the probable source of the oil and gas of middle Kentucky. Specimens that have been tested have yielded as high as 10 gallons of oil to the ton. If the full thickness of the Chattanooga under Barren County is as rich in petroleum as 10 gallons to the ton of shale, every square mile of the shale, where 50 feet thick, contains about 27 million barrels of oil. The shale is surely an adequate source of all the oil in the oil-bearing rocks which in the total is but a small proportion of the oil originally contained in the Chattanooga. The main problem is that of migration from the source to the now existing productive reservoir rock, or oil ("sand"). For a discussion of this problem see United States Geological Survey Bulletin 688 on Allen County.

The Chattanooga actually yields oil apparently in paying quantities in two wells of the Etta Oil Co., near the mouth of Boyds Creek. The oil occurs about 25 to 30 feet below the top of the shale which there is about 50 feet thick.

At some points gas under great pressure has been encountered in the Devonian, as for example on the Furlong farm about 4 miles west-southwest of Glasgow, where the gas pressure was sufficient to compel cessation of drilling. The areal extent of any accumulations of gas is not known.

Fort Payne Formation

In the Austin pool on Beaver Creek 3 miles north of Glasgow amber oil occurs just above the Chattanooga shale. Amber oil occurs also in two wells at Coles Bend

in the southwest corner of the county approximately about 50 feet above the Chattanooga. Similar oil in small quantities is present in the Fort Payne in the Oskamp-Boyds Creek pool. It is probably of quite general occurrence in small quantities and may be locally in commercial quantity. Its horizon seems to be about that of the Beaver Creek "sand" of Wayne County or 50 feet or so higher. Gas in large amounts is present in the Fort Payne in the Hiseville regions where it has been tapped by at least 5 wells. Its horizon is about 70 feet above the top of the Chattanooga shale. The greatest pressure and flow is at the well on the Thompson or Anderson farm about 5 miles northeast of Hiseville in Metcalfe County. Here the flow is reported at the rate of nearly 5 million cubic feet daily, after long confinement. Its permanency is undetermined. The area outlined by the 5 wells is of considerable extent and must contain a large volume of gas.

Oil and Gas Below the Silurian

In Barren and surrounding counties both oil and gas have been found at a number of places in rocks older than Silurian, at depths ranging from 100 to 800 feet below the Chattanooga ("Black") shale. The only occurrence of oil at such depth reported in Barren County is in a well on Beaver Creek about 3 miles northwest of Glasgow where a small quantity of black oil was obtained at the depth of about 1,400 feet or about 1,125 feet below the Chattanooga shale. The famous old American well on Cumberland River in Cumberland County a few miles north of Burkesville, which is estimated to have produced 50,000 barrels of oil, is a striking example of the rare oil possibilities of depth greater than 20 feet below the Chattanooga shale in Barren County and, with rare exceptions, greater than 100 feet in Allen County. The oil horizon of the American well is, according to Safford, State Geologist of Tennessee for many years, who reported on the well in 1866, 215 feet below the Chattanooga, in rocks classified by him as the Nashville group (of Upper and Middle Ordovician age), and which are now known to belong to the Maysville group, of the

Upper Ordovician or Cincinnatian series. They are also commonly known as "Hudson River beds" or "Hudson beds." Another example is the wells in the big loop of Cumberland River about 10 miles west-southwest of Burkesville, drilled in 1900-1902. The oil is said to be found 700 or 800 feet below the Chattanooga shale. Still another example is the Sunnybrook pool in the southwestern part of Wayne County where the oil occurs 500 to 550 feet below the Chattanooga. All these deeper deposits of oil are in limestone of Trenton age, the top of which is probably 500 to 600 feet below the Chattanooga shale. Gas under strong pressure, encountered in two wells in the Oskamp locality 3½ miles south of Glasgow at the depth of 600 feet below the Chattanooga, is also probably in beds of Trenton age. The boundary between the beds of Trenton age and the overlying formations of Cincinnatian age can not, for various reasons, be precisely determined so that the exact depth of the top of the Trenton horizon is unknown. It should be noted that there are in this region no strata of the character of the oil rock of Ohio that is commonly called Trenton, which is a cavernous dolomite of so distinctive a nature as to be surely identifiable. The absence of the Ohio so-called Trenton oil rock may be due to either of two causes: First, the so-called Trenton "sand" may have no representative here, being in Ohio a formation lying between the highest Trenton horizon of this region and the overlying Cincinnatian shale; second, it may be represented by the highest Trenton horizon of this region but of an entirely different lithologic character. The first explanation is probably the true one.

As the rocks of Trenton age in this part of Kentucky probably do not exceed 400 feet in thickness, their bottom is not over 1,000 feet below the Chattanooga and drilling to greater depths in search of oil "sand" of this age will be futile. So far as known to the writer, the Sunnybrook and Cumberland River occurrences are the only discoveries of oil in commercial quantities in rocks of Trenton age in Kentucky. A number of wells have been drilled into or through these rocks in Barren and adjacent counties without finding either oil or gas. While

pools in the Trenton or higher Ordovician limestones other than those named probably exist in these rocks it is likely that they are so few, small and scattered that efforts to locate them will be attended with far more failures than successes.

Developments

Drilling in Barren County began in 1865 with the old Kenslow well on Boyds Creek, to be described, and has gone on intermittently ever since. Oil in paying quantities has been discovered in at least eight different pools, none of which, however, have been delimited by proven dry territory. These pools somewhat in the order of their development and importance are named and numbered below:

No. 1. Oskamp-Boyds Creek pool
No. 2. Winlock-Steffy pool.
No. 3. Oil City pool.
No. 4. Jordan pool.
No. 5. Gas Hollow pool.
No. 6. Harrison pool.
No. 7. Austin pool.
No. 8. Russo pool.

No. 1. Oskamp-Boyds Creek Pool

In 1865 a well was drilled on the Kenslow farm on Boyds Creek 3½ miles south of Glasgow, the location being made there because of a strong oil seep in the bed of the creek. This well struck oil in large quantity, the bottom of the oil-bearing rock being 15 to 20 feet below the Chattanooga ("Black") shale and therefore in the Devonian limestone. The well is reported to have yielded 24 barrels daily for at least 12 years, at which rate, if production was continuous, it would have yielded 105,000 barrels in the 12 years. Another good well drilled in 1868 near the mouth of Boyds Creek is known as the Trigg well. No statistics of production from it were obtained. In the meantime it is estimated that about 100 wells have been drilled along Boyds Creek including those in the north end of the pool, the Oskamp and Hoffman group,

and in the southern half of the pool, the Etta and Moneta groups of wells. A great majority of these wells are productive or potentially so. Of these, according to Mather, seven wells in the Oskamp group were pumping 10 or 12 barrels daily in 1917. Of the Hoffman group of wells, recently drilled, it was reported in 1919 that eleven were producing six barrels daily. There are said to be 20 wells potentially productive in the Etta group, but owing to lack of transportation and other causes, these wells have not been active in recent years and their actual capacity has not been proven. No information was obtained about the Moneta group. The oil in the Oskamp-Boyds Creek pool is said to be about 38 Baume'.

No. 2. Winlock-Steffy Pool

The Winlock-Steffy pool includes four groups of wells belonging to the Jenkins Oil Co., Beech-Haven Oil Co., Iowana Oil Co., and a group of four recently drilled on the Winlock farm by the Karl Oil Co., north of the Lower Bowling Green road, five miles west of Glasgow. There are also included an oil well and a gas well on the Furlong farm. The Jenkins group includes the old Steffy well drilled 30 years ago, now said to be producing about three barrels a day, and the Beech-Haven group includes the old Winlock well also drilled 30 years ago and now reported to be pumping four barrels per day. In all the Jenkins group has five wells pumping with a production of 10 barrels daily. The best one of these, recently drilled, yields four barrels. There are two other wells with oil, not producing and two dry holes. The Beech-Haven group has three wells pumping five barrels daily and four dry holes. The Iowana Company has six wells with oil and three dry holes; production unknown. The wells drilled by the Karl Oil Co., four in number, include two good producers in the Devonian limestone and two light producers, the oil in which is believed to come from a depth of 60 feet below the Chattanooga shale and therefore below the Devonian limestone which was unproductive in those wells. One of these Winlock wells made a large showing and is believed to be good for 25 barrels daily. Of the wells on the Furlong property one

is a very strong gas well, the pressure having been strong enough to blow out the cap rock before it was quite penetrated by the drill. In this pool are a few dry holes and two new wells with fair showings of oil which have not been proven by actual production. With the exception of the two wells on the Winlock deriving their oil from the Silurian all the wells of this pool are supposed to be deriving their oil from the Devonian.

No. 3. Oil City Pool

The Oil City pool was opened up about 1890. It is said to contain seven producing wells. A well in this pool is said to have produced 40,000 barrels. The present production is unknown. A refinery was built and operated for a time utilizing the oil from these wells. The oil is said to be derived from within 15 to 20 feet below the Chattanooga.

No. 4. Jordon Pool

The Jordan pool includes the old Haven-Chase group of wells drilled about 1887, of which five produced either green or amber oil in amounts varying from 3 to 50 barrels daily. The amber oil occurs 105 feet above, and the green oil below the Chattanooga shale.

No. 5. Gas Hollow Pool

The Gas Hollow pool 1½ miles west-northwest of Haywood seems to include four oil wells, 2 gas wells, and one dry hole. These were drilled many years ago. One of the gas wells was so strong that the sound of the escaping gas could be heard in Glasgow and one of the oil wells made a big showing of oil.

No. 6. Allison Pool

The Allison pool on Beaver Creek about 2½ miles northwest of Glasgow includes four wells of small capacity said to derive their oil from about 90 feet below the Chattanooga and therefore from limestone of Silurian age.

No. 7. Austin Pool

The Austin pool, about one mile northeast of the Allison, includes a small gas well and two small oil wells deriving amber oil from just above the Chattanooga, at the horizon of the Beaver Creek oil "sand" of Wayne County.

No. 8. Russo Pool

The Russo pool includes four producing wells and a drilling well all belonging to the Marshall Oil Co. The four wells produce six barrels daily from the Devonian limestone, within 15 feet below the Chattanooga. Oil was present at this horizon in the drilling well but it was cased off as the well is intended to be drilled to the depth of 2,000 feet.

The oil produced from these wells is made into gasoline by a small plant located on the property.

Scattered Wells

Besides the wells included in the described pools there are numbers of scattered oil or gas wells and of dry holes, many of which are located on the map. The report, however, is not complete in this respect.

Some of the more important are two wells showing amber oil in the Fort Payne, in the vicinity of Coles Bend in the southwest corner of the county; two wells on the Lawrence farm ½ mile west of Berry's store, one estimated at 100 barrels capacity; and two wells on the Panye farm about one mile northeast of Berry's store, one of which is estimated at 10 barrels capacity and the other showing only salt water. A well on the J. R. Reed farm, 2½ miles south of Glasgow Junction, has a good show of oil. A gas well on the Craig farm in the same locality is estimated at a capacity of 2,000,000 cubic feet per day. A well near Mathews mill about 6 miles south of Glasgow, has a good showing of oil but is not yet producing. Some fifteen scattered wells along Beaver Creek between Oil City and a point one mile southeast of Coral Hill that have been drilled in the last thirty years or more, are reported to have either oil or gas or both in paying

quantities at present prices. One of these is a strong gas well on the Duff farm on Beaver Creek about ¾ mile west of the Louisville and Nashville pike. The gas is so heavily laden with Hydrogen Sulphide that when it is permitted to escape the fact can be detected at a long distance by the odor, and silverware in the neighboring houses and silver coins in the pocket are soon coated with black silver sulphide by the action of the gas. This well is said to be capable of yielding 1,000,000 cubic feet per day. Its depth is about 400 feet, the gas, if from that depth, being about 150 feet below the Chattanooga and therefore probably near the contact of the Silurian and the Ordovician. There are four strong gas wells in the vicinity of Hiseville (see page 168) the capacity of which has not been determined by actual production. A small gas well is located in the village itself. It yields enough only for a few houses.

Some Characteristics of the Devonian Oil-Bearing Stratum ("Sand")

As exhibited in the sections of figure 1, the Devonian oil "sand" is locally absent in the unconformity between the Silurian and Devonian systems. To what extent such a condition prevails throughout the county is of course unknown, although it is reasonable to assume that there are other occurrences besides the one on Barren River, described (pages 157-8). In the Cumberland River drainage, the Devonian is everywhere absent but the eastern border of its extent beneath cover is unknown. There is a sufficient degree of possibility that the border is somewhere in eastern Barren County to make that part of the county suspicious territory. Drillings from immediately beneath the Chattanooga shale should be taken from every well drilled in that part of the county and submitted to some competent geologist for examination until the question is determined. The Devonian seems to be generally present in other parts of the county, although the failure of some wells may be attributed to its absence.

As in all strata, there is considerable variation in the composition and texture of the oil "sand" from place to

place and a well located on a close textured spot into which no or but little oil could penetrate, would be dry or have only a show of oil. Such a condition would account for dry holes even where structure and surrounding productive wells would indicate a favorable location.

Another character of the Devonian oil "sand" is the distribution of quartz sand in it. In places quartz sand is present, in others apparently absent (compare sections Nos. 1 and 3, Fig. 1). The amount and distribution of the quartz sand would exercise a potent control over the absorption and distribution of oil. A circumstance described by Mr. Horace Coombs, field manager for the Jenkins Oil Company, is illustrative. In Jenkins No. 5 well by exercising effective methods of observation, Mr. Coombs was enabled to locate the source of the oil in a layer of brown, coarse-grained sandstone six inches thick. It is Mr. Coombs' theory, seemingly a reasonable one, that in wells with only a color or a very small showing of oil only a thin oil-bearing sandy layer was penetrated on the feather edge of a layer that is thicker elsewhere.

Such conditions as those just proposed will explain many of the eccentricities of the distribution of the oil in the "sand" as revealed by the drill. The location of wells in relation to the structure will explain other vagaries. A few examples will be of interest. On the Winlock farm, five miles west of Glasgow, is a good well now, at the age of 30 years, pumping about four barrels daily; on the Steffy farm, 600 feet distant, is another well, 30 years old, now pumping about three barrels. Midway between the two is a dry hole. On the same Winlock farm just north of the Lower Bowling Green road, in the head of the small stream, shown on the map, is a group of four wells in a line north and south. No 1, just north of the road, is a good producer from the Devonian "sand;" in No. 2, 300 feet north, the Devonian "sand" is dry and a little oil was obtained in Silurian limestone 60 feet below the Chattanooga shale; No. 3, still 300 feet further north of No. 2, made a sensational showing from the Devonian "sand" and is believed to be good for 25 barrels daily; No. 4, 300 feet north, was dry in the Devonian but was drilled to the depth of No. 2 where a little oil was found. Such facts as those just related clearly indicate the ir-

regularity of the distribution of the oil in the "sand," due to its internal constitution, such as local difference in porosity and composition.

As an example of the narrow limitations of distribution, probably due to structure, may be cited the situation at the Moulder property in the southeast corner of Warren County where a dry hole with salt water is located about 300 feet from a good oil producer and not over 600 feet from a gusher rated as a 1000-barrel well. The dry hole is down the dip from the producing wells in the salt water zone.

The lesson to be drawn from such circumstances as those just described is that a single dry hole is not a conclusive test for a given locality nor a sufficient cause for discouragement in more or less well proven productive territory.

In the case of irregular distribution of the oil in the "sands" no rule can be discovered for guidance, since the conditions are probably mainly due to accidents of original deposition of the oil-bearing rock and are unpredictable at the surface. In the case of structure, some rules of limited application can be deduced. In the first place, the longer axes of the anticlines have a prevailing northeast-southwest trend. If, therefore, either gas or salt water is encountered in a test well other tests should be made either to the northwest or southeast at usual location distances. In case of entirely hidden small structures it would be impossible to determine, except by drilling, in which direction the summit of the fold lies. But, as probably most of the anticlines are narrow, one or two wells in either direction should indicate which way the axis lies. If oil should be encountered in the first test well the best rule would be to locate the next wells northeast and southwest of the first in order to obtain a clue as to the probable linear extent of the field. If such tests should prove successful, wells should be drilled to the northwest and southeast to prove the width of the productive belt and locate the axes of the folds. The application of this rule is limited to the flanks of anticlines. It obviously would not apply if the test well should happen to be located on the pitching northeast or southwest end of a fold.

Analysis of Crude Oil—Oskamp Pool.

Laboratory No. G-3878. Petroleum, labeled "Green crude oil, freshly pumped sample, from Oskamp pool, Boyds creek, Barren county, Ky. Pay sand, Onondaga. Collected by W. R. Jillson, November 3, 1919." Sample, a thin, green oil, dark brown by transmitted light.

Specific Gravity, 0.839, Equivalent to 36.0° B.

Distilled below 150° C. (302° F.)	18.1%	(Gasoline fraction)
Distilled from 150° to 300° C. (302-572° F.)	46.3%	(Burning oil fraction)
Brown tar	35.0%	
Loss in analysis	0.6%	
Total	100.0	

It began to distill at 80° C. (176° F.)

(Tested by A. M. Peter)

ALFRED M. PETER, Chief Chemist,
Kentucky Agricultural Experiment Station.

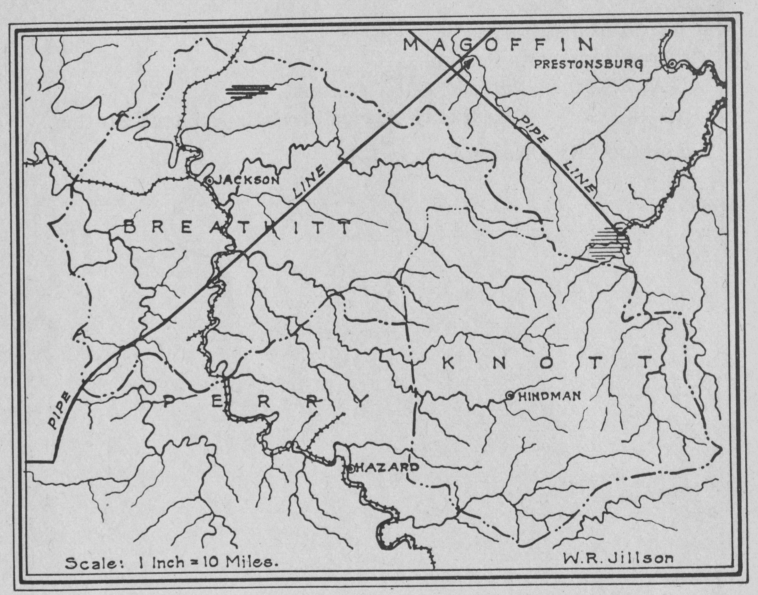
Lexington, Ky., November 7, 1919.

THE OIL AND GAS GEOLOGY OF BREATHITT AND KNOTT COUNTIES.

By Williard R. Jillson,
Kentucky State Geologist.

Introduction

The area upon which this report is based occupies a central position in the hill region or what is commonly called the "Mountains" of Eastern Kentucky. This section lies between 37° 10′ and 37°and 45′ north latitude and 82° and 45′ and 83° and 45′ west longitude. Geographical-

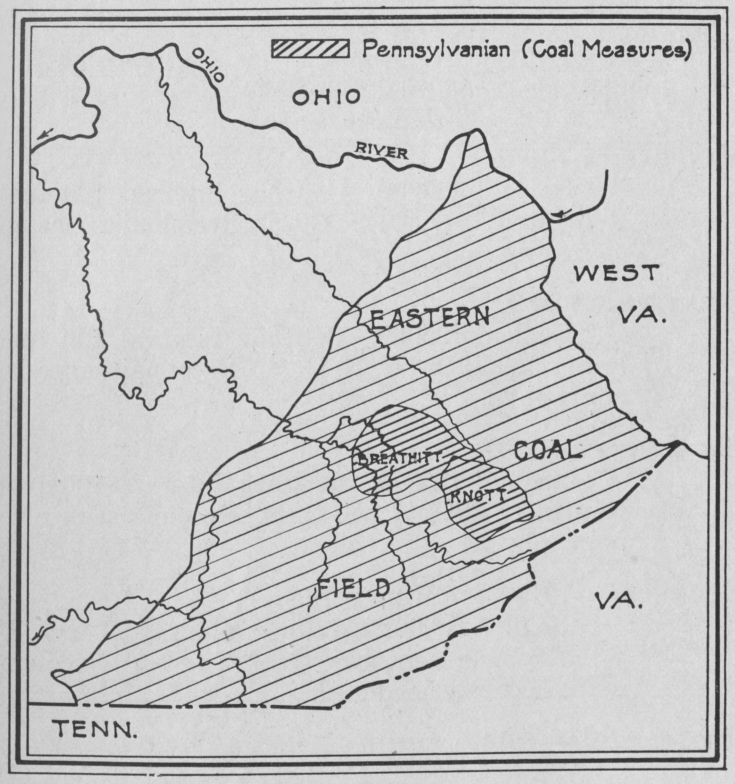


Sketch map of Breathitt and Knott Counties, Ky., showing drainage and railroads.

ly this area is the central interior of the Eastern Kentucky Coal Field. The principal towns within the section are Jackson, county seat of Breathitt County, on the North Fork of the Kentucky River, and Hindman, county seat of Knott County, on the headwaters of Troublesome Creek, a northwest flowing tributary of the North Fork of the Kentucky River.

Field Work

The field work upon which this report is based, including the accompanying structural maps, was done by the writer and Mr. Iley B. Browning, Assistant Geologist. The writer made six geological reconnaissances of both Breathitt and Knott counties during the years 1917, 1918 and 1919. The structural mapping was done by Mr. Browning, during the spring and summer of 1919. The



Sketch map showing location of Breathitt and Knott Counties in the Eastern Kentucky Coal Field.

levels were run from bench marks of known elevation above sea level. Radiating elevations were placed from these points on the Fire Clay Coal, which was used as the key bed.

Annotated Bibliography

The published literature relative to the oil and gas of Breathitt and Knott counties is very scant indeed. Much has been written on the coals of this section and their sequences and thicknesses are now very well understood. The stratigraphy and structural geology of this section, however, have received practically no attention at all. The following bibliography of maps and reports it is believed completely covers all publications touching directly on the oil and gas geology of these two counties.

Topographic Maps
(30′ Minute Base.)

Manchester—1891
Scale 1-125000. Contour interval 100 feet. Reprinted 1917. U. S. G. S. Reconnaissance topography.

Beattyville—1892
Scale 1-125000. Contour interval 100 feet. Reprinted 1916. U. S. G. S. Reconnaissance topography.

Salyersville—1899
Scale 1-125000. Contour interval 100 feet. Reprinted 1918. U. S. G. S. Reconnaissance topography.

Buckhorn—1913 (15′Minute Base.)
Scale 1-62500. Contour interval 50 feet. U. S. G. S. and Kentucky Geol. Survey. Excellent map, accurate in detail.

Troublesome—1914
Scale 1-62500. Contour interval 50 feet. U. S. G. S. and Kentucky Geol. Survey. Excellent map, accurate in detail.

Whitesburg—1915
Scale 1-62500. Contour interval 50 feet. U. S. G. S. and Kentucky Geol. Survey. Excellent map, accurate in detail.

Hindman—1915
Scale 1-62500. Contour interval 50 feet. U. S. G. S. and Kentucky Geol. Survey. Excellent map, accurate in detail.

Pikeville—1916
Scale 1-62500. Contour interval 50 feet. U. S. G. S. and Kentucky Geol. Survey. Excellent map, accurate in detail.

Prestonsburg—1918
Scale 1-62500. Contour interval 50 feet. U. S. G. S. and Kentucky Geol. Survey. Excellent map, accurate in detail.

GEOLOGICAL MAPS

Proctor, John R.—1891
Preliminary map of Kentucky, Kentucky Geological Survey. Scale 20 miles equal one inch. Very general and inaccurate. Designates coal measures as the exposed strata of Breathitt and Knott counties. (Out of print.)

Proctor, John R.—
Map of Kentucky. Eclectic Geographies. Scale 26½ miles equal one inch. A reconnaissance geological map of Kentucky very generalized and inaccurate. Shows the surface rocks of Breathitt and Knott counties to be those of the coal measures entirely. (Out of print.)

Hoeing, J. B.—1907
Preliminary map of Kentucky. Kentucky Geological Survey, Series IV, scale 1 inch equals 10 miles. Showes the aerial geology of Breathitt and Knott counties to be Pennsylvanian. (Out of print.)

SELLIER, L. M.—1915

Preliminary map of Kentucky. Kentucky Geological Survey, Series IV, scale one inch equals 10 miles. Shows aerial geology of Breathitt and Knott counties to be Pennsylvanian.

1917

SELLIER, L. M.—

(Same as above.)

GEOLOGICAL REPORTS

OWEN, DAVID DALE—1857

Coal measures. Kentucky Geological Survey, Series I, third report of the Geological Survey in Kentucky. Chapter I, pages 9-30, Discusses coal measure correlations and on page 30 states that "a similar coal series exists in Breathitt County" as that in the neighboring counties of Morgan, Wolfe and Owsley. First definite stratigraphic reference. (Out of print.)

MOORE, P. N.—1878

Report on the geology of a section from near Campton, in Wolfe County, to the mouth of Troublesome Creek, in Breathitt County. Kentucky Geological Survey, Series I. (N. S. Shaler, Director), pages 255-284, and also reprint Kentucky Geological Survey, Series II (John R. Proctor, State Geologist), pages 254-289, 1884. Discusses the coal measure stratigraphy and structure of northwestern Breathitt County along general lines. (Out of print.)

HODGE, JAMES M.—1885

Preliminary report on the geology of parts of Letcher, Harlan, Leslie, Perry and Breathitt counties. Kentucky Geological Survey, Series II, Vol. C., Part 2, pages 35-52a. Also An. Report, Kentucky Inspector of Mines, 1901-1902. General structural relations outlined. Description of coal openings and sequences. (Out of print.)

Preliminary report on the geology of the Lower North Fork, Middle and South Forks, Kentucky River. Kentucky Geological Survey, Series II, Vol. C., Part 2, pp. 57-114; also An. Report, Kentucky Inspector of Mines, 1901-1902. Stratigraphic and structural references to Breathitt County. Principally a description of coal openings and sequences. (Out of print.)

HOEING, J. B.—1905

Oil and Gas Sands of Kentucky. Kentucky Geological Survey, Series III, Bull. I, 233 pages and three maps. Many references to oil and gas sands of Breathitt and Knott counties, including well logs. (Out of print.)

HODGE, JAMES M.—1910

Report on the Coals of the Three Forks of the Kentucky River. Kentucky Geological Survey, Series III, Bull. II and one large map. Analyses and descriptions of the coals of this section of Kentucky. (Out of print.)

MILLER, ARTHUR M.—1910

Coals of the Western Border of the Eastern Coal Field. Kentucky Geol. Surv., Series III, Bull. 12, 83 pp., 7 pls. (maps and sections). Discusses Pottsville in general and Breathitt and Lee formations. Maps a small section in the northwestern part of Breathitt county. (Out of print.)

FOHS, F. JULIUS—1912

Coals of the Region Drained by the Quicksand Creeks. Kentucky Geological Survey, Series III, Bull. 18, Serial 25. Contains stratigraphic sequence of the coals; detailed section and analyses. Eight sketch maps. This report is essentially an operator's and prospector's guide to the coals of this section of Breathitt County.

HODGE, JAMES M.—1913

Coals of the North Fork of Kentucky River, in Perry and Knott counties. Kentucky Geological Survey, Series IV, Vol. I, Part II, pages 923-986. Operator's description of coals and analyses.

Coals of Upper Carr Fork and the Big Branch and Bull Creek Region of North Fork of Kentucky River. Kentucky Geological Survey, Series IV, Vol. I, Part II, pages 987-1036. Operator's description of coals and analyses.

HODGE, JAMES M.—1918

Coals of the North Fork of the Kentucky River, in Perry and portions of Breathitt and Knott counties. Kentucky Geological Survey, Series IV, Vol. III, Part III, 418 pages. Descriptions of the coals, their sequence, etc. Operator's guide.

JILLSON, W. R.—1919

Structural Deformation and its Relation to Proven Oil and Gas Accumulation in Eastern Kentucky. Department of Geology and Forestry of Kentucky, Series V, Mineral and Forest Resources, Vol. I, No. 2, Paper No. 1. One map. References to Breathitt and Knott County Structure. (Out of print.)

The Low Sulphur Coals of Kentucky. Department of Geology and Forestry of Kentucky, Series V, Mineral and Forest Resources, Vol. I, No. 2, Paper No. 8. Gives stratigraphic sequence for Breathitt and Knott counties. (Out of print.) 1919.

The Oil and Gas Resources of Kentucky. Department of Geology and Forestry of Kentucky, Series V, Bull. I. Discusses Oil and Gas Geology, structure, stratigraphy, well logs and development of Breathitt and Knott counties. 1919.

PHYSIOGRAPHY

The area under discussion forms a unit with the remainder of the "Mountain" section and is essentially a maturely dissected northwestward sloping plateau. The valleys are "V" shaped and narrow; the ridges knife-like and irregular. There is no single extensive area of flat or plain land in either county, the largest flats occurring only in the big meandors of the North and Middle Forks of the Kentucky River.

The lowest elevation in Breathitt County is found at the point where the North Fork of the Kentucky River enters Wolfe County. This elevation is about 650 feet. The highest point in Breathitt County is 1685 feet, which is found at the head of Jake's Fork of the Laurel Branch of Troublesome Creek, in the southeastern section of the county, on the Perry County line. The elevation of Jackson is lower than a medial position between these two extremes, the elevation of the L. & E. railroad station at Jackson being 762 feet. The relief in Breathitt County varies between 450 feet and 700 feet, the highest relief being found on the headwaters of the creeks, on the ridges bordering Breathitt and Perry, on the south, and Breathitt and Magoffin on the north.

The lowest point in Knott County is found at the mouth of Jones' Creek, where it empties into Right Beaver Creek, and is 700 feet above sea level. Occurring on Right Beaver Creek, a tributary stream to the Levisa Fork, this low point belongs in the drainage basin of the Big Sandy River. The lowest point in Knott County in the Kentucky River drainage is found on the boundary of Breathitt and Knott counties, on Buckhorn Creek, at the mouth of Cole's Fork. This elevation is 866 feet, giving the minimum Kentucky River drainage an increased elevation over the minimum Big Sandy River drainage of 166 feet. The highest points in Knott County are between 2,250 and 2,300 feet. These are found in the ridge divide between Knott and Letcher counties, in the vicinity of Omaha post office, on the head of Carr's Fork of the North Fork of the Kentucky River. The maximum elevations of Yellow and Chestnut Mountains, which are found in the north central portion of Knott County, be-

tween the Kentucky River and the Big Sandy River drainage basins, are from 1,750 feet to 1,800 feet above sea level. There are in Knott County, however, especially in the southeastern section, many elevations of 1,800 and 1,900 feet. The elevation of Hindman (U. S. G. S., B. M.) is 1,032 feet. The differences in relief in the Big Sandy River drainage basin amount to about 1,500 feet between the highest and lowest points. The differences of relief in the Kentucky River drainage basin amount to 1,200 feet between the highest and lowest points. An average relief of from 600 to 800 feet is common throughout Knott County between ridge elevation and elevations in the creeks immediately below.

Drainage

The principal drainage lines are the North and Middle Forks of the Kentucky River, which flow northwestward, respectively, across the central and western portions of Breathitt County. Smaller tributary streams are Frozen Creek, Quicksand Creek and Troublesome Creek, of the North Fork of the Kentucky River, in Breathitt County, and Carr's Fork, Ball's Fork, Laurel Fork, Middle Fork, Jones' Fork, Caney Creek and Dry Creek, of Knott County. The Knott County drainage is all headwater drainage, the streams of the western portion of this county flowing into the North Fork of the Kentucky River, and the streams of the eastern portion of the county flowing into Right Beaver Creek, of the Levisa Fork of the Big Sandy River. The streams individually afford excellent examples of entrenched meandors. Collectively they illustrate splendidly the entrenchment of entire drainage systems. Rapids or waterfalls are very rare, and swamped or ponded areas are unknown. Due to the clastic silicious nature of the sediments of this section, mechanical factors are the important erosive agents, solution playing a very minor part. The area is covered with a thick stand of original and secondary growth timber, chiefly of the broad leaf varieties of oak, maple, poplar, etc. The heavy stand of timber, coupled with thick undergrowth of bushes and smaller vegetation, has resulted in obscuring the stratigraphy of the section to a very marked degree, making geological work very difficult.

Transportation

The roads, with the exception of those points where they cross the ridges, are always found down in or alongside of the creeks. No automobile roads and very few good wagon roads are found in either county. Horseback riding is the common method of travel. The Louisville & Nashville Railroad following the North Fork of the Kentucky River bisects Breathitt County, but no passenger railroad crosses or enters Knott County. The Beaver Creek division of the Chesapeake & Ohio Railroad serves Hindman, however, through Lackey Station in Floyd County.

Stratigraphy

The exposed or surface rocks of Breathitt and Knott counties are, with the exception of small amounts of unconsolidated alluvial deposits along the larger streams, all of marine or semi-marine sedimentary origin. Omitting the coals and one or two rather thin calcareous horizons these sedimentary rocks are all clastics, that is, they are composed of a material of a fragmental nature, derived by mechanical erosional means from other older land surfaces, and have all been deposited in or by water.

Excepting the river alluvium, which is a recent deposit, all of the exposed rocks in this section belong to the Alleghany and the Pottsville divisions of the Pennsylvanian system. The principal exposures are those of the Wise-Kanawha or Upper Pottsville, which section attains a maximum thickness of between 1,200 and 1,500 feet in this region. The representatives of the Alleghany are found only in a few of the higher ridges, where they exist as isolated remnants of a one time continuous and blanketing formation. In both the Alleghany and the Pottsville there are found many coal seams, but due to their restricted aerial distribution and high position, the coals of the Alleghany are economically unimportant and few. The sequence of the important commercial coals of

the Pottsville, as now known in advance of any considerable amount of coring beneath the drainage levels, is given herewith. The area of elevation is that adjoining Lambric post office, on Quicksand Creek, Breathitt County. It may be pointed out that these elevations are variable at all points, heightening with the thickening interval to the southeast, and lessening with the corresponding thinning of the intervals to the northwest.

COALS OF THE WISE-KANAWHA UPPER POTTSVILLE

	Alt. Feet.
Hindman coal	1400
Interval 80 to 100.	
Flag coal (No. 7)	1335
Interval 40 to 80.	
Hazard coal (No. 6)	1275
Interval 100 to 150.	
Haddix coal (No. 5)	1093
Interval 200 to 235.	
Fire Clay coal (No. 4)	850
Interval 30 to 50.	
Whitesburg coal	800
Interval 120.	
Amburgy coal.	
Interval (unknown).	

From the Amburgy coal down to and below drainage there is an undetermined thickness of the Upper Pottsville, the coals of which in Breathitt and Knott counties are imperfectly known. Beneath these lie the representatives of the Norton-New River or Middle Pottsville, and the representatives of the Lee-Pocahontas or Lower Pottsville, which sub-surface formation completes the Pennsylvanian system in this section.

Beneath the Lowest Pottsville are found representatives of the Mississippian System, Devonian System, Silurian System and Ordivician System. A complete generalized section for this region, including the exposed surface rocks as well as the underlying, below drainage strata, has been prepared and is here presented.

STRATIGRAPHIC SEQUENCE ABOVE AND BELOW DRAINAGE IN BREATHITT AND KNOTT COUNTIES

	Minimum Thickness Feet	Maximum Thickness Feet
PENNSYLVANIAN SYSTEM		
Alleghany, Upper Pottsville	1000	1500
Drainage Average Level.		
Upper Pottsville, Middle Pottsville, Lower Pottsville	500	1650
MISSISSIPPIAN SYSTEM		
Mauch Chunk, Ste. Genevieve-St. Louis, Waverly	800	1000
DEVONIAN SYSTEM		
Black Shale, Onondaga Limestone	300	400
SILURIAN SYSTEM		
Niagara, Clinton	175	300
ORDOVICIAN SYSTEM		
Trenton, Lower Strata		(unknown)

As stated above, the rocks of the Alleghany and the Pottsville of the Pennsylvanian System, with the exceptions already noted, are clastics—gritty shales, true silicious sandstones and sandy conglomerates. The rocks of the Mississippian System may be subdivided into the (1) Mauch Chunk, (2) St. Genevieve-St. Louis, and the (3) Waverly. The Mauch Chunk is composed of alternating sandstones and pinkish or reddish to purple shales, which grade downward into bastard limestones. The St. Genevieve-St. Louis group is composed of two distinct and easily recognized thick and compact limestones, with a thin sandstone parting. The Waverly consists in downward succession of alternating shales and sandstones, most of which in the upper section have a pinkish or red color. Toward the base of the Waverly the sections show

a thick succession of sandy and limy shales of light gray to blue color, which is terminated by a thin dark shale, the Sunbury, and a thin sandstone of tan or gray color. This sandstone may or may not be a fingering out of the well known Berea. The Devonian System is composed of two members, the Black Shale, correlative to the Ohio, Chattanooga, and Genesee shales. Beneath this is found a true magnesian limestone, somewhat cherty, which is the correlative of the Onondaga limestone and is commonly known as the Corniferous from its cherty or hornstone lithological characteristic. This limestone may be porus or compact. It is the Irvine sand of drillers and is the horizon which is chiefly productive to the north and northwest of Breathitt County, in the Estill-Lee-Wolfe-Powell section. Beneath the Devonian, the Silurian System presents an increasingly limy tendency, with alternating hard, sandy and shaly limestones, which exhibit variegated colors, from gray to green to pink. The pronounced reddish limestone horizon found toward the base of this system is the Clinton, well known among drillers, and is easily recognized by its reddish color. The Ordivician System underlying the Silurian presents a monotonous succession of compact limestones, shaly limes, and irregularly distributed thin sand lenses. Nothing lower than Ordivician has ever been touched by the drill in either Breathitt or Knott County, as the Ordivician System in this section is extremely thick.

The Pottsville and Mauch Chunk

The stratigraphy of Breathitt and Knott counties, simple in its general conceptions, presents many specific irregularities and complications. The outstandingly important feature found in all formations above the Devonian is that of extreme irregularity, and a general progressive thickening especially in the Pottsville from the northwest towards the southeast. This thickening in the Pottsville, a perfectly definite and easily demonstrated fact, may be counted upon with certainty to change the sub-surface structure to some extent over that which is seen and mapped at the surface on any of the coals or other less dependable and definite indexes

or key bed horizons. Below the Pottsville the thickening in the underlying formations down to the Devonian is not nearly as noticeable or as important.

The irregularity of the surficial as well as the subsurface stratigraphy of these two counties may be said to be both inter-formational and inter-systemal. The Pottsville, of the Pennslyvanian, and the Mauch Chunk, of the Mississippian, illustrate perhaps to the best advantage the great irregularity in sequence of sands and shales, hardly any two well records exhibiting the same intervals or corresponding lithology. With the exception of the Beaver sand in the Pottsville, which is generally easily recognized, due to its thickness and persistency, the sands and shales present an extremely variable succession. There are, however, in the Pottsville three important oil and gas sands. These are the Beaver, Horton and Pike. Occasionally at the base of this section there is found a rather thick sand in addition to the above named three, which may be called the Stray or Salt sand.

Between the Mauch Chunk and the Pottsville there exists in this part of Kentucky a very great unconformity, with the result that the Mauch Chunk, which has been channelled and cut up by the currents of the earliest Pottsville embayment, presents an extremely variable thickness. The Pottsville in many places has been dropped down into channelled incisions in the Mauch Chunk. At such places records show additional sands in the Pottsville and a very thin representation of the Mauch Chunk. In other and closely adjoining locations a greater or complete section of the Mauch Chunk is frequently found. In such places the Mauch Chunk generally gives one or two definite, true silicious sands, which are oil and gas bearing. These sands are intercalated between thick pinkish to reddish shales. The chief productive horizon in the Mauch Chunk is the Maxon sand, a name brought to Kentucky from West Virginia, where the sand was first found productive and became established. This sand has not shown any large production to date in Breathitt County, but is very productive in Knott and the adjoining county of Floyd. It is also

productive in a limited way to the southwest of Breathitt County, in Knox County.

The St. Genevieve-St. Louis-Waverly Group of the Mississippian System is perhaps the most regular and most easily recognized horizon in all of the sub-surface stratigraphy, with the exception of the Devonian Black Shale. The St. Genevieve-St. Louis Group sand inclusion is productive of gas in Knott County toward the head of Rock Fork on the Bolin farm, and this horizon may be looked to for further gas production in other sections of Breathitt and Knott counties. The upper part of the Waverly, commonly known as the Big Injun, offers one or two sands, which are productive of gas. The possibility of oil production from this horizon is, however, somewhat remote, though it is a fact that these rocks do produce a small quantity of oil in some parts of eastern Kentucky. No sands of importance from a commercial standpoint are recognized in the lower Waverly. The Wier and Berea sands, when followed along the outcrop to the northwest, are seen rapidly to thin to the south and probably do not extend far enough south to cover this entire area, at least as an important oil and gas sand. The Wier, however, at almost every point where it has been drilled has given shows of oil, even as far south as the well at Wolf Coal in Breathitt county.

The Black Shale, Onondaga Limestone, and Lower Strata

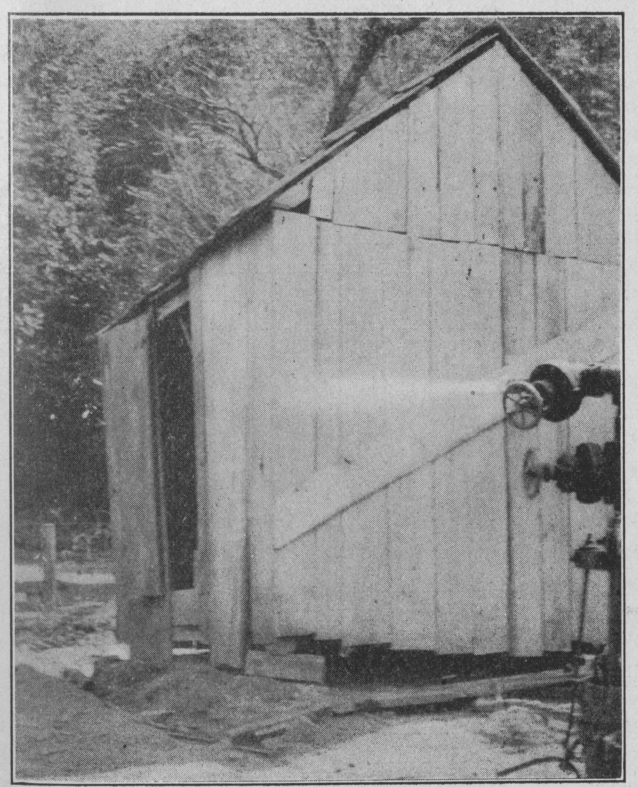
The Devonian Shale has not been drilled into production at any point within these two counties, though it occasionally exhibits a sandy lense-like phase. The Onondaga, or "Corniferous" Limestone, underlying the Black Shale has been penetrated by the bit in many places, but has to date proven unproductive in this whole area, except in a few wells in the northwesternmost part of Breathitt County, where small production has been obtained. Lower than the Onondaga no oil or gas sands of importance are recognized to date in the Niagara or the Trenton in either of these counties, and were any such sands ever to be found productive, they would only be reached at considerable depth.

BREATHITT COUNTY

LOG No. 1.

OLD WELL ON FROZEN CREEK.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Clay	12	12
White sand	53	65
Bastard lime (?) Oil show	2	67
White sand	73	140



A BREATHITT COUNTY GASSER.

This well is located on the Wilhurst Anticline and produces about 3,000,000 cubic feet of natural gas, with a rock pressure of 500 pounds. Notice the frost on the tubing. This well was drilled by the Big Six Oil Co. Photo by W. R. Jillson. 1919.

LOG No. 2.

J. H. WINTERBOTHAM FARM.
Little Frozen Creek.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	11	11
Sand	90	101
Slate	50	151
Sand	274	425
Slate	30	455
Sand	30	485
MISSISSIPPIAN SYSTEM.		
Lime "Big Lime"	175	660
Sand	50	710
Shale (Waverly)	400	1110
Brown shale (Sunbury)	10	1120
Sand (Berea?)	35	1155
DEVONIAN SYSTEM.		
Brown shale	218	1373
Sand (?)	3	1376
Lime	11	1387
Brown lime—oil	11	1398
Sand (?)	6	1404

LOG No. 3.

BRECK CRAWFORD FARM.
Mouth of Cope's Branch.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	8	8
Lime	22	30
Sand	55	85
Slate	15	100
Sand	62	162
Slate	5	167
Sand	13	180
Slate	90	270
Sand	80	350
Slate	7	357
White sand	80	437
Brown slate	3	440

MISSISSIPPIAN SYSTEM.		
Sandy lime	3	443
Sandy slate	29	472
Sandy lime	18	490
Slate	16	506
Lime—"Big Lime"—Gas at 620	204	710
Sandy shale	10	720
White shale	32	752
Sand	143	895
Sandy shale	290	1185
DEVONIAN SYSTEM.		
Brown shale	159	1344
Black shale	3	1347
Lime shell	1	1348
Sandy shell	14	1362
Black shell	18	1380
Brown lime	20	1400
White lime	35	1435
Sandy lime—oil and water at 1460	112	1547
Blue sandy shale	10	1557
Brown lime	10	1567

LOG No. 4. HARGIS FARM.
Four miles up South Fork of Quicksand Creek.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Sand and gravel	12	12
Sand	53	65
Coal	2	67
Slate	23	90
Coal	2	92
Sand	10	102
Slate	43	145
Coal	3	148
Sand	10	158
Slate	9	167
Coal	3	170
Slate	70	240
Sand	10	250
Slate	37	287
Sand	60	347
Slate	10	357
Sand	200	557
Slate	93	650
Sand	200	850
Slate	5	855
Sand (Base of Pottsville)	115	970

MISSISSIPPIAN SYSTEM.		
"Little lime"	25	995
"Pencil cave"	5	1000
"Big lime"	190	1190
Blue sand	100	1290
Red rock	40	1330
Sandy slate	175	1505
*"Berea Grit" (?)—Oil and gas show	70	1575
Slate	30	1605
DEVONIAN SYSTEM.		
Black shale (Devonian)	275	1880
White slate	30	1910
Lime	114	2024
Slate	2	2026

LOG No. 5. DAVIS FARM.

7 miles up South Fork of Quicksand Creek.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Sand	15	15
Slate	25	40
Lime	10	50
Slate	425	475
Sand	100	575
Slate	10	589
Sand	30	615
Slate	5	620
Sand	280	900
Slate (Base of Pottsville)	90	990
MISSISSIPPIAN SYSTEM.		
"Little lime"	25	1015
White sand	55	1070
Lime	10	1080
Slate	15	1095
Lime	21	1116
"Pencil cave"	2	1118
"Big lime"	182	1300
Blue sand	80	1380
Red rock	77	1457
Slate	108	1565
Sand	10	1575
Slate	37	1612
Wier	40	1652
Break	9	1657
"Berea" (?)	68	1725

*The Berea probably does not extend as far south as the well.

DEVONIAN SYSTEM.		
Black slate	305	2030
White slate	25	2055
SILURIAN SYSTEM.		
Lime	175	2230
Sand	60	2290
Slate	40	2330
Red rock	70	2400
Blue slate	50	2450
Red rock	50	2500

LOG No. 6.

WELL ON WOLF CREEK AT WOLF COAL.

Big Bird Oil & Gas Co.

T. H. Drake, Contractor and Driller.

(Partial record.)

Strata	Thickness		Total Depth
PENNSYLVANIAN SYSTEM.			
Top soil	10		10
Broken lime	5		15
Blue slate	115		130
Sand	15		145
Slate	5		150
Sand	25		175
Shale	2	Cased with 177-8¼	177
Black slate	123		300
Sand	150	Called salt sand	450
Shale	100		550
Sand	126		676
Coal	10		686
Shale	150		836
Sand	84		920
MISSISSIPPIAN SYSTEM.			
Shale	80		1,000
Sand	70	Showing of oil	1,070
Red rock	30		1,100
Lime shell	5	Cased with 6¼ casing	1,105
Sand	50		1,155
Shale	50		1,205
Broken lime	45		1,250
Big lime	115	Oil and Gas flowed 60 hours	1,365
Big lime	50		1,415
Lime shell	10	Green in color	1,425
Shale	90	Red rock	1,515

*Berea probably not this far south.

Blue slate	150		1,665
Sand	50	Wier	1,715
Shale	35	Green	1,750
Shale	30	Light	1,780
Sand	20	Berea	1,800
Shale	15	Pink	1,815
Shale	15	Light	1,830
DEVONIAN SYSTEM.			
Brown shale	210		2,040
Shale	10	Light	2,050
Brown shale	25		2,075
Sand shale	25		2,100
Corniferous lime	100	In and still drilling.	

LOG No. 7. ELKATAWA.

Well on Caney Creek near ELKATAWA.

R. A. Chiles, et al.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	1	20
Pottsville	565	585
MISSISSIPPIAN SYSTEM.		
Shale	55	640
Little lime	13	653
Shale	2	655
Big lime	145	800
Big Injun	90	890
Red rock slate	385	1275
Berea	25	1300
DEVONIAN SYSTEM.		
Brown shale	260	1560
White slate	7	1567
Cap rock	25	1592
Sand (small oil flow)	1	1593
Sand (small salt water flow)	3	1596
Hard dry sand	.....	.....

(This record incomplete.)

LOG No. 8.

BIG BRANCH OF NORTH FORK NEAR HADDIX.

PENNSYLVANIAN SYSTEM.

Strata	Thickness	Depth
Surface	8	8
Sand rock	12	20
Shale	2	22
Coal	3	25

Blue mud	5	30	
Sand rock	15	45	
Water sand	5	50	top water
Sand rock	7	57	
Black shale	13	70	
Blue mud	40	110	
Blue grit	55	165	hard.
Black shale	60	225	
Sand rock	25	250	
Blue shale	10	260	
Fire clay	8	268	
Sand rock	12	280	
Blue mud	45	325	
Sand rock	15	340	
Black mud	50	390	
Sand rock	181	571	hard.
Black slate	37	608	
Sand rock	50	658	
Black slate	87	745	3' coal.
Sand rock	185	930	
MISSISSIPPIAN SYSTEM.			
Red rock	5	935	
White slate	5	940	
White grit	170	1110	100' in water.
Slate	30	1140	
Lime	20	1160	
Slate	8	1168	
Big lime	222	1390	
Black lime	20	1410	
Lime shells	10	1420	
Shale	5	1425	
Red rock	40	1465	Big Injun.
Brown shale	30	1495	
Blue slate	55	1550	
Lime shell	25	1575	
Slate	184	1759	
DEVONIAN SYSTEM.			
Brown shale	253	2012	
Blue mud	2	2014	
Brown shale	42	2056	
Fire clay	12	2068	
Sand (Corniferous Limestone)	212	2180	

(Base of Devonian and top of Silurian occur in the last 235 feet and the change was not noted by the driller.)

91974

KNOTT COUNTY

LOG No. 9.

WELL AT THE MOUTH OF MILL BRANCH OF BALLS FORK.
5½ miles north of Hindman.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	10	10
Light shale	10	20
Sand	4	24
Coal	5	29
Dark slate	5	34
Gray sand	32	66
Coal	3	69
Light slate	15	84
Sand	16	100
Slate	20	120
Gray sand	27	147
Coal	3	150
Black slate	16	166
White sand	44	210
Coal	4	214
Black slate	34	248
Gray sand	15	263
Light slate	60	323
White sand	12	335
Light slate	30	365
Coal	4	369
Dark slate	70	439
Gray sand	12	451
Light slate	54	505
Sand	20	525
Black slate	128	653
White sand	37	690
Dark slate	62	752
White sand	25	777
Shelly slate	188	965
White sand (Beaver)—Gas and salt water	215	1180
Black slate	20	1200
Sand (Horton)	126	1326
Dark slate—Salt water	12	1338
White sand (pike and salt)—Salt water	312	1650
(All in Pottsville.)		

LOG No. 10. J. M. CONLEY FARM.
Head of Salt Lick of Right Beaver.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Drift	22	22
Slate	30	52
Sand	20	72
Coal	2	74
Dark slate	45	119
Gray sand	3	122
Dark slate	23	145
White sand	49	194
Slate	54	248
White sand	47	295
Dark slate	50	345
White sand	48	393
Dark slate	45	438
White sand	30	468
Dark slate	70	538
Gray and white sand (Beaver and Horton)	300	838
Coal	2	840
Dark slate	39	879
Gray and white sand (Pike)—Salt water	105	984
Dark slate	25	1009
Gray sand	15	1024
Slate	156	1180
White sand (salt sand)—Oil and salt water	28	1208
(All Pottsville.)		

LOG No. 11. WEBB FARM.
Right Beaver above Jones Fork.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	35	35
Coal	5	40
Sand	40	80
Black slate	80	160
Light slate	70	230
Coal	3	233
Slate and sand	207	440
White sand (Beaver)	40	480
Slate	20	500
White sand (Horton)—Gas, oil and salt water	220	720
Slate	5	725

Sand (Pike)--Salt water	127	852
Slate	35	887
Black sand	25	912
White sand (salt sand)	94	1006
Black slate (base of Pottsville). (All Pottsville.)		

LOG No. 12. WM. TRIPLETT FARM.
Jones Fork of Right Beaver.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM		
Sand and gravel	31	31
Slate	9	40
Coal	3	43
Slate and shells	80	123
Black shale	27	150
Sand	50	200
Slate	30	230
Sand	20	250
Black slate and shells	150	400
Sand—Gas	10	410
Slate	25	435
Sand (Beaver)	180	615
Slate	30	650
Sand (Horton)	130	780
Slate and sand	100	880
Sand (Pike)—Black oil at 990	110	990
Black slate	10	1000
Slate and shells	51	1051
Sand (salt sand)	45	1096
(All Pottsville.)		

LOG No. 13. LINDSAY TRIPLETT FARM.
Jones Fork of Right Beaver.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	36	36
Slate	6	42
Black sand	160	202
Gray sand	110	312
Slate and shells	160	472
Gray sand (Beaver)	100	572
Slate	5	577
White sand (Horton)—Salt water	203	780
Slate and shell	75	855
Black sand	20	875

Slate	25	900
White sand (Pike)	125	1025
Slate	25	1050
White sand	75	1125
Slate	20	1145
White sand (Salt sand)	30	1175
Black slate	5	1180
White sand —Salt water	32	1212
(All Pottsville.)		

LOG No. 14. WM. INMAN FARM.
Rock Fork of Right Beaver.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	24	24
Slate	30	54
Sand	12	66
Slate	19	85
Coal	2	87
Slate	45	132
Sand	15	147
Slate	41	188
Sand—Salt water	45	233
Slate	68	301
Sand	8	309
Slate	127	436
Sand	20	456
Slate	6	462
Sand	18	480
Slate	8	488
White sand	79	567
Slate (Beaver)	3	570
White sand —Gas and salt water	115	685
Slate	2	687
Sand	22	709
Slate	38	747
White and gray sands (Horton)—Salt water	124	871
Black slate	2	873
Gray sand—Oil show	20	893
Black slate	2	895
White sand (Pike)—Salt water	121	1016
Black slate	35	1051
White sand (salt sand)—Oil and salt water	106	1157
(All Pottsville.)		

LOG No. 15. ESTHER HORTON FARM.
Rock Fork of Right Beaver.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	21	21
Slate	100	121
Sand	14	135
Slate	41	176
Sand	36	212
Slate	3	215
Sand	35	250
Slate	151	401
Sand	9	410
Slate	35	445
White sand (Beaver)	213	658
Coal	2	660
Sand	30	690
Coal	2	692
Slate	31	723
Sand (Horton)—Oil	89	812
Slate	12	824
Black sand	11	835
Black slate	9	844
Sand	13	857
Slate	5	862
White sand (Pike)—Gas, oil and salt water	136	998
Black slate	17	1015
Sand (salt sand)—Gas	124	1139

(All Pottsville.)

LOG No. 16. ANDY COBURN FARM.
Rock Fork of Right Beaver.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Drift	26	26
Slate	38	64
Sand	16	80
Coal	6	86
Slate	9	95
Sand	20	115
Slate and red shale	145	260
Coal	8	268
Slate	67	335
Sand	50	385
Slate	77	462

Sand		10	472
Slate		74	546
Sand (Beaver)—Oil and gas		148	694
Slate		14	708
Sand (Horton)—Salt water		115	823
Slate		14	837
Gray sand, Slate, White sand	—Salt water (Pike)	120 / 28 / 126	957 / 985 / 1111
Slate		35	1146
Sand and slate		27	1173
Gray and white sands, Black slate, White sand	—Salt water (Salt sand) —Salt water	31 / 18 / 41	1204 / 1222 / 1263

(All Pottsville.)

LOG No. 17. ANDY COBURN FARM.
Rock Fork of Right Beaver.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	20	20
Slate	39	59
Sand	21	80
Slate	12	92
Coal	8	100
Sand	42	142
Slate	48	190
Sand	48	238
Slate	242	480
Sand (Beaver)—Gas and salt water	228	708
Slate	44	752
Sand	20	772
Slate—Salt water	16	788
Sand—(Horton)	63	851
Black slate	12	863
Gray sand	9	872
Black slate	9	881
White sand, Black slate, White sand	(Pike)	52 / 4 / 82	933 / 937 / 1019
Black slate		28	1047
White sand, Slate and shells, White sand	(Salt sand —Salt water	51 / 21 / 29	1098 / 1119 / 1148

(All Pottsville.)

LOG No. 18. ROCK FORK JUST BELOW BRUSHY FORK.
Lessor, W. R. Bolen No. 1. Total depth 1,635 feet.

Strata	Thickness	Depth
Drift 20 feet 10" casing		20
PENNSYLVANIAN SYSTEM.		
White sand	5	25
Coal	5	30
Dark slate	120	150
Dark sand 8" casing	30	180
Slate	5	185
Sand	30	215
Coal	5	220
Slate	20	240
Sand	70	310
Slate	15	325
Sand	95	420
Slate	15	435
Sand	45	480
Slate	280	760
Sand	148	908
Break	2	910
Sand (water at 950)	80	990
Break	10	1000
Sand (little oil at 1060 feet)	170	1170
Slate	10	1180
Sand	40	1220
MISSISSIPPIAN SYSTEM.		
Limestone	20	1230
Sand	40	1270
Slate	30	1300
"Maxon" sand (a little water and oil at 1305)	123	1423
[illegible] slate	14	1437
Sandstone, light sandy	13	1451
Slate and shells	25	1476
Little lime	15	1491
Pencil cave	9	1500
"Big lime"		
Gas in Big Lime at 1630	135	1635

4,680,000 cu. ft. gas, open flow 540 pounds rock pressure.
Well completed July, 1916. 1637 2" tubing.
Not shot. Elevation 945 feet.
1440 6⅝" casing.
A. B. Brode and Son, Contractors. S. L. Anderson, Driller.
135 feet not the full thickness of the Big Lime formation which in this locality should be about 160 to 180 feet thick.

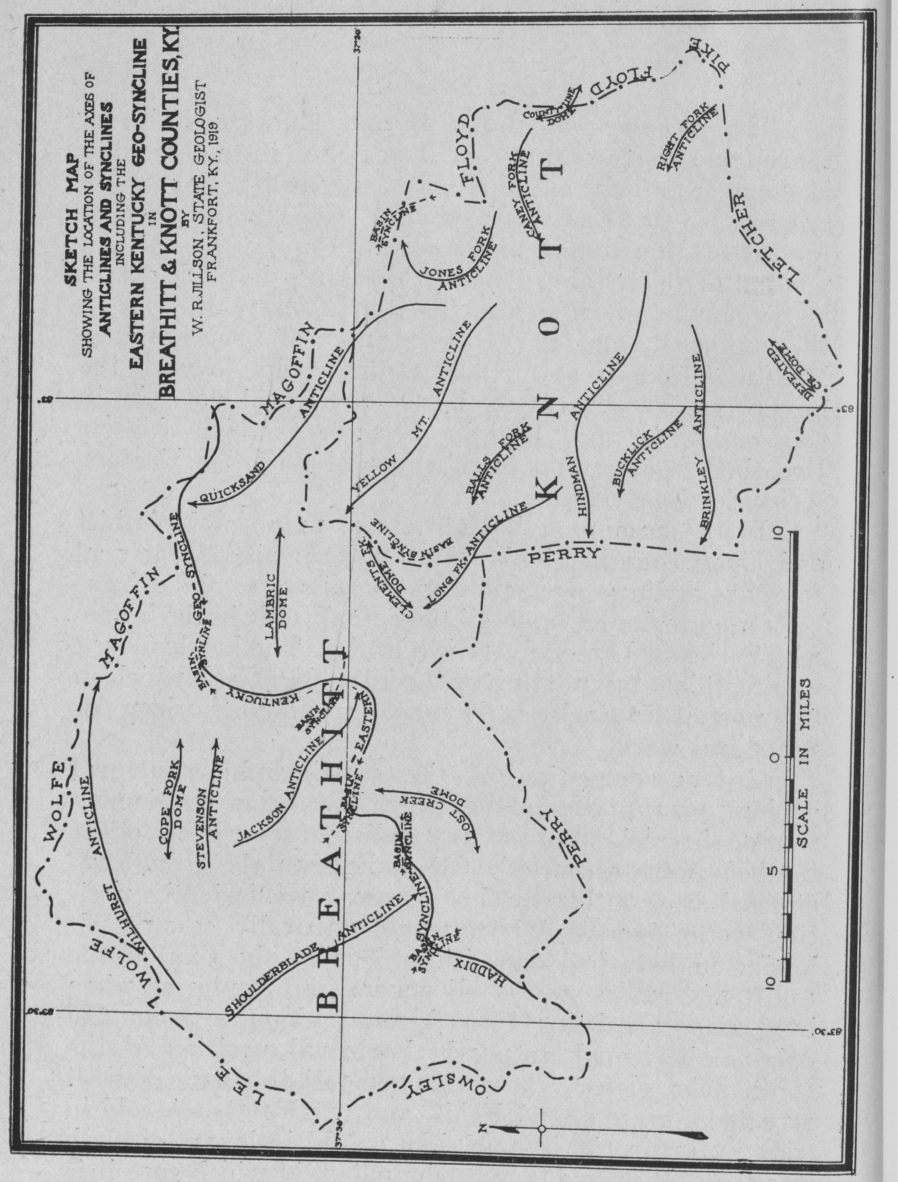
STRUCTURE

General Statement

The structure of Breathitt and Knott counties is thoroughly representative of that found throughout the Eastern Kentucky Coal Field. Breathitt County is crossed by the Eastern Kentucky Geosyncline, which fact places this area in the structural basin of the eastern portion of this State. Broadly speaking the rock strata of the northwestern part of Breathitt County dip toward the southeast, and the rock strata of southeastern Breathitt County and Knott County dip toward the northwest. The line of the lowest structural elevation in this region is the Haddix Syncline, which bisects Breathitt County and is coincidental with the Eastern Kentucky Geosyncline.

In the accompanying structural maps of Breathitt and Knott counties, by Mr. Iley B. Browning, structural contours or lines of equal elevation above sea level have been used to depict in detail the actual folds in the Kanawha Series or Upper Pottsville Rocks. The key bed used was the flint clay parting of the Fire-clay Coal, which in this part of Kentucky is the most dependable horizon for structural work.

A true conception of the stratigraphic-structural geology presupposes a time when, following the deposition of the rock strata of any sedimentary region, all of the beds were essentially flat or horizontal, through restricted areas at least. This of course would be the position water deposited beds would naturally occupy following undisturbed deposition. During the time of the uplift and emergence of all marine sedimentaries when land areas are being formed, many changes from the original horizonal or nearly horizonal position of the strata take place. These changes fall into two distinct structural groups: (1) Folds, and (2) Faults. A fold in sedimentary rocks is much like a fold in layers of cloth or paper. It may either be elongated, in which case it is called an anticline; or somewhat rounded, in which case it is called a dome. In each case this kind of fold re-



sembles an arch or an inverted "U." Down folds or "U" like depressions in rock strata are called synclines or structural basins. The second great group of structural features are faults, which are simply breaks, more or less perpendicular down through the rock strata, which have been attended by vertical or horizontal displacement. Both folds and faults are the result of crustal stresses and strains, and their varying figures are structural translations of the force expended against the normal strength of the rocks of the deformed area.

In Breathitt and Knott counties the important structural features are those of the folded order. While many small faults may be noted at various points throughout these two counties, none of them has a displacement of over ten feet. Most of the faults have a displacement of a foot or less. Because of this fact they could not be shown to advantage on a structural map with a ten foot contour interval. Their significance is entirely local and is not considered in this area of any special importance to oil or gas accumulation.

Structure of Breathitt County

Breathitt County occupies a trough position in the structure of Eastern Kentucky. The Haddix Syncline enters the county from the southwest at the point where the Middle Fork of the Kentucky River crosses the Perry County line. It takes a serpentine course to the northeast, leaving Breathitt and passing into Magoffin County on the north headwaters of Hawes' Fork, of Quicksand Creek. The Haddix Syncline in its course passes close to Crocketsville on the Middle Fork of the Kentucky River, Copland and Haddix, on the North Fork, and Rousseau on Quicksand Creek. Generally it crosses and re-crosses the Cumberland Pipe Line, which is essentially in a synclinal position in Breathitt County.

There are four anticlines and three domes of importance in Breathitt County. These are—as indicated on the map—the Willhurst Anticline, in the northwestern part of the county; the Shoulder Blade Anticline, in the western part of the county, between the Middle and North Forks of the Kentucky River; the Jackson and

the Stevenson Anticlines, in the central part of the county; the Cope's Fork Dome, in the northern part of the county, between Frozen Creek and Cope's Fork; the Lambric Dome, in the eastern part of the county, between North and South Quicksand Creeks, near Lambric post office; Clement's Fork Dome, in the eastern part of the county, overlapping the Knott County line; and the Lost Creek Dome, in the southern part of the county, south of Lost Creek post office. Of these structures the Willhurst Anticline, the Shoulder Blade Anticline, the Stevenson Anticline, the Jackson Anticline and the Cope's Fork Dome are on the northwest flank of the Haddix Syncline, and the Lambric Dome, Clement's Fork Dome and the Lost Creek Dome are on the southeastern flank of the Haddix trough.

BLOWING TAULBEE NO. 3.

This well is on the Wilhurst Anticline, in northern Breathitt County, and produces 4,750,000 cubic feet of natural gas. It has a rock pressure of 500 pounds. It is the property of the Big Six Oil Co. Photo by W. R. Jillson. 1919.

Willhurst Anticline

The major axis of this anticline is crescentric from southwest to east and falls from an elevation of 1,180 feet on the North Fork of the Kentucky River to an elevation of 940 feet on the head of Hunting Creek, of Quicksand Creek. The Willhurst Anticline has been drilled on Johnson and Boone Forks of Frozen Creek, on Main Frozen Creek, and on the Sulphur Branch of Clear Fork of Frozen Creek, with a total of twelve wells. Three of these on the Boone Fork produced oil, but in small quantity; three of these produced gas in large quantity; four were dry holes and two were drillings. The gassers occupy a high or crestal position on the structure, the oil coming at lower points.

Shoulder Blade Anticline

This structure extends southeastward from the Lee County line as a more or less definite structure between the Middle and North Forks of the Kentucky River. It has had but two wells drilled on it, on the headwaters of Twin Creek, a tributary of the Middle Fork of the Kentucky River, and one near Elkatawa, on Caney Creek, a tributary of the North Fork of the Kentucky River. Both of these wells were dry. There is a structural drop on the Shoulder Blade Anticline to the southeast from 1160 feet to 900 feet just southwest of Copland.

Jackson Anticline

The Jackson Anticline, the major axis of which extends southeastward from a point just east of Jackson to the head of Russell Fork of Troublesome Creek, has had two dry holes drilled on either side of it at very low structural positions. There is a fall in this anticline from an elevation of 1010 feet to an elevation of 840 feet.

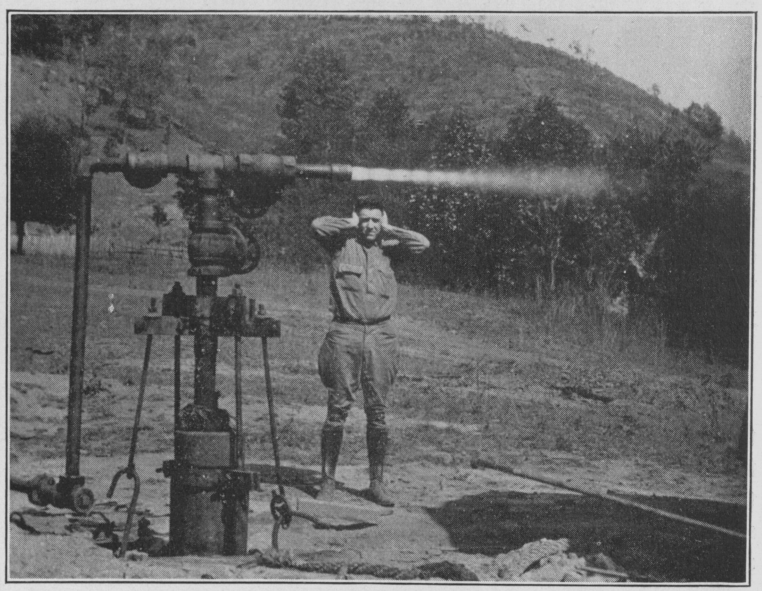
Stevenson Anticline

This anticline lies about two miles south of Cope's Fork Dome, between Frozen Creek and Quicksand Creek.

Its major axis runs almost east and west and falls from an elevation of 1050 feet to 830 feet. It is undrilled.

Haddix Syncline

The Haddix Syncline in Breathitt County is coincident with the Eastern Kentucky Geosyncline. As such it is the line of the lowest structural elevation in this part of the state. This syncline is characterized in Breathitt County by a series of five closed basin synclines. These are, progressing from southwest to southeast, (1) the Crockettsville Basin Syncline; (2) the Middle Fork Basin Syncline; (3) the Copland Basin Syncline; (4) the Smith Branch Basin Syncline; and (5) the Rousseau Basin Syncline. These synclinal cups are located from two to four miles from each other and show either two or three closed contours. Their structural depth therefore is between twenty and thirty feet and in this sense they are exactly



BLOWING THE TAULBEE NO. 2.
This well located in northern Breathitt County, on the Wilhurst Anticline is producing 5,750,000 cubic feet of gas with a rock pressure of 500 pounds. It is owned by the Big Six Oil Co. and has not yet been commercialized. Photo by W. R. Jillson, 1919.

comparable to the three domes in Breathitt County, whose closed structural elevation is about the same. The Haddix Syncline enters Breathitt County from Perry at at elevation of 860 feet and passed into Magoffin at an elevation of 830 feet. Its lowest point in Breathitt County is found at Rousseau, where it is only 780 feet above sea level.

Cope's Fork Dome

This structure lies between Clear Creek and Cope's Fork of Frozen Creek. It is quite elliptical in figure and exhibits a closure to the west of 20 feet. The structural drop to the southeast is sharp and the rise to the west and northwest is gradual. One well has been drilled on Cope's Fork which has produced gas. It was drilled in a rather low position on the southern flank.

Lambric Dome

This structure lies on the southeast side of the Haddix Syncline, between North and South Quicksand Creek. It is in reality a doming anticline, the closure to the east only amounting to about 15 feet. Pronounced synclinal areas finger into it from both the north and the south to such an extent as to suggest that it is in reality an arrested dome of much larger proportions. It is undrilled.

Lost Creek Dome

The Lost Creek Dome shows a long major axis in a north and south direction, with a closure of 20 feet to the east. This structure, with a highest elevation of 900 feet, is essentially in the bottom of the Eastern Kentucky Geosyncline, since it is only about 35 feet above the nearest point of the axis of the Haddix Syncline. It is undrilled.

The Structure of Knott County

The structural features of Knott County are nearly as well defined as those of Breathitt County. Knott County is entirely located on the southeastern flank of the Eastern Kentucky Geosyncline. At no point is it there-

fore as low structurally as is Breathitt County. The normal dip is to the northwest. Within general limits this dip is uniform, but is somewhat lower and flatter to the northwest of Hindman, and considerably higher and steeper to the southeast of the same town. In general the dip of this section averages between 15 and 25 feet to the mile.

In Knott County there are five large and four small anticlines; two domes and two basin synclines. The large anticlines are (1) Quicksand Anticline; (2) Yellow Mountain Anticline; (3) Long Fork Anticline; (4) Hindman Anticline; and (5) Brinkley Anticline. The smaller anticlines are (1) Jones' Fork Anticline; (2) Right Fork Anticline; (3) Bucklick Anticline; and (4) Caney Fork Anticline. The domes are (1) County Line Dome, and (2) Defeated Creek Dome. The synclines are (1) Buckhorn Basin Syncline and (2) Rock Fork Basin Syncline. The detail of these structures is as follows:

Quicksand Anticline

The Quicksand Anticline is the northernmost anticlinal structure in Knott County. It is in reality also a Breathitt County structure, but is discussed with the Knott County structures since it has its inception at an elevation of 1090 feet on Rock Fork of Right Beaver Creek, in Knott County. Its major axis runs to the northwest in the form of the letter "S," passing into Breathitt County at the head of Middle Fork of Quicksand Creek and following down the Spring Fork of Main Quicksand, where it swings around to the north, crosses Hawes' Fork and meets the Haddix Syncline at an elevation of 850 feet. Its structural fall is 240 feet. It is a pronounced structure throughout its course, but shows a decided tendency towards terracing or doming on the headwaters of Spring Fork of Quicksand Creek. One dry hole has been drilled on the head of it, in Knott County, on the headwaters of Saltlick Creek.

Yellow Creek Anticline

The Yellow Mountain Anticline paralells in a measure the Quicksand Anticline, about three or four miles to the south. Its highest elevation is 1120 feet, found on the ridge between Jones' Fork of Right Beaver and Ball's Fork of Troublesome. Its major axis extends toward the northwest and is located at an elevation of 880 feet. The structure of this anticline is the same as that of the Quicksand Anticline. This structure is undrilled.

Lost Creek Anticline

The Lost Creek Anticline rises about five or six miles south of the Yellow Mountain Anticline, at an elevation of 990 feet, on Ball's Fork. It drops to an elevation of 880 feet, on Long Fork of the Troublesome Creek, just south of Clement's Fork Dome. It is undrilled.

Hindman Anticline

The Hindman Anticline starts at an elevation of 1320 feet at the head of Caney Fork of Right Beaver and extends in a serpentine course downward to the west and northwest to an elevation of 920 feet, exhibiting a fall of 400 feet. This structure is quite pronounced southwest of Hindman, but is less pronounced to the northwest. It is undrilled.

Brinkley Anticline

The Brinkley Anticline rises in the region between the Right Fork of Troublesome Creek and Carr's Fork, about one mile south of Brinkley Post Office, at an elevation of 1250 feet. Its major axis extends almost due west, the structure disappearing on Lost Creek, near the Perry County line, at an elevation of 970 feet. The structural fall of this anticline is therefore 280 feet. In its easternmost part this anticline is pronounced, but its configuration is not as well defined to the west of Lost Creek. This structure is undrilled.

SMALLER ANTICLINES

Jones' Fork Anticline

The Jones' Fork Anticline rising on the Bear Branch of Jones' Fork, in the northeastern part of Knott County, extends in a crescentric form to the north of Rock Creek, where it descends to the Floyd County line. Its highest point, which is found on Bear Branch, is 1140 feet, and its lowest point, which is found on Rock Creek, is 1050 feet, giving a structural fall of 90 feet. The lower part of the Jones' Fork Anticline has been drilled at a number of points and shows production in the Pottsville. Since, however, the writer considers the production associated with adjoining structure, further reference to production on this structure will be omitted.

Caney Fork Anticline

This structure rises on Sly Branch of the Right Fork of Beaver Creek and extends in an open crescent to the northwest and west, crossing Big Branch of Caney Fork. Its highest point on Sly Branch is 1310 feet and its lowest point, which is on Gibson Creek, of Caney Fork, is 1200 feet, giving it a structural fall of 110 feet. This structure has been drilled, with a dry hole on Caney Fork, just above Big Branch.

Right Fork Anticline

The Right Fork Anticline is very small and is found in the southeastern part of Knott County, on the headwaters of Right Fork of Beaver Creek, its highest point occurring within a half mile of the head of Puncheon Branch, at an elevation of 1660 feet. Its lowest point is a mile below Ivan, on Bill D. Branch of Right Beaver Creek. The elevation here is 1490 feet, giving it a structural fall of 170 feet. This structure has never been drilled.

Bucklick Anticline

This small structure is in reality a north finger of the Brinkley Anticline. It finds its inception at an elevation of 1140 feet, near the head of Elklick Fork on Young's Fork of Lost Creek. Its major axis extends to the northwest in the ridge between Clear Creek of Troublesome Creek. Its lowest point occurs about one mile south of the Emmalena Post Office, at an elevation of 1000 feet, giving it a structural fall of 140 feet. It is undrilled.

DOMES

County Line Dome

This small dome is located in the eastern portion of Knott County and overlaps into the south-nipple of Floyd County. It is found on the head of the Old House Branch of Right Beaver Creek, and is in total area not more than a mile square. Three ten feet contours close about it, giving it a structural height of slightly more than thirty feet. This structure is undrilled.

Defeated Creek Dome

This structure is located in the southernmost portion of Knott County, one-half mile south of Cody Post Office, on Defeated Creek, a headwater tributary of Carr's Fork. This structure is a small one comparable in size to the County Line Dome to the northeast. With two closed contours, it shows but slightly more than 20 feet in height. It is undrilled.

BASIN SYNCLINES

Buckhorn Basin Syncline

The Buckhorn Basin Syncline, the most pronounced cup syncline in Knott County, is found in the northwestern portion of the county, adjoining the Breathitt County

line, on Buckhorn Creek. It shows two closed contours and is about 20 feet in depth. No wells have been drilled in this syncline.

Rock Fork Basin Syncline

The Rock Fork Basin Syncline is located on Rock Creek, of Right Beaver, and lies partly in Knott and partly in Floyd counties. It is a rather large flat elongated synclinal basin, showing only one closed ten-foot contour. A considerable amount of drilling has been done in this structural depression and with success, oil production being secured from the Beaver, Horton and Pike, of the Pottsville, and Maxon of the Mauch Chunk. Gas production in small amounts has been secured from all of the above named sands and in addition from the underlying Big Injun, of the Mississippian System. The development in this section of Knott and Floyd counties is old, the first well having been drilled in but a few miles to the north of the Knott County line, on Right Beaver Creek, at the mouth of Saltlick in Floyd County, by Louis H. Gormley, in 1891. Production was secured in this original well, the Howard Purchase No. 1, in the Lower Pottsville. Since this many wells have been drilled in this vicinity, extending the pool so as to cover practically all of this synclinal basin. Though an old field, new drilling in this vicinity has resulted in bringing in new production apparently as good as that of the original wells, many of which are still producing, though not nearly so largely as formerly.

Summary

It is difficult in as large an area as that covered by Breathitt and Knott counties to pick out the areas which may be expected to produce. It is also equally as hard to point out the unfavorable sections. The amount of drilling which has been done in these two counties demonstrates, however these facts. Production, either of oil or gas, is usually found associated with anticlinal or doming structure. This is true in northwestern Breathitt County and again in eastern Knott County.

It is not true, however, in connection with the oil production secured on Rock and Jones' Fork of Right Beaver, at which point the oil production is synclinal, as interpreted from surface observations. In Breathitt County a large number of dry holes have been drilled off of structure, and a very few have been drilled on structure. In the same county the wells which have been drilled in absolutely synclinal or basin synclines have not shown to date production as has the Rock Fork Basin Syncline of Knott and Floyd. However, a very small number of wells have been drilled in the basin synclines of Breathitt County, and it may be pointed out that the possibility of the Pottsville Sands in this section have not yet either been exhausted or thoroughly tested. Generally the structure of Breathitt County is more pronounced and in this same measure more favorable to oil and gas accumulation than it is in Knott. On the other hand, the structure in Knott County rises to an elevation 500 feet higher than the highest contour in Breathitt County and for this reason it may be expected to draw from a larger area. The development in Knott County is in its infancy, only two localities having received any attention at all. These are the Rock and Jones' Fork sections, and the Right Beaver section. In both of these localities production in the Pottsville and Mauch Chunk has been secured. A dry well was drilled several years ago on Mill Branch of Ball's Fork, north of Hindman, which did not reach the Big Lime of the Mississippian System. For this reason the fuller productive possibilities of the underlying sands in this section of the state are unknown. A large number of the anticlines mapped and described in this report are in fact nothing more than low plunging folds without the slightest indication of closure of contours. This kind of a structure is not considered more favorable for oil and gas accumulation than a single Monocline. The very pronounced anticlines like the Willhurst, and the closed structures like the Copes Fork Dome should, however, receive careful drilling considerations as they may be looked to for both oil and gas production.

GEOLOGY OF ALLEN COUNTY.

By Arthur McQuiston Miller

Professor of Geology, University of Kentucky.

INTRODUCTION

Field Work

The field investigations on which the following report is mainly based extended over about six weeks of the summer of 1919. The writer had previously paid three visits to the county, one in 1896, when he examined the oil spring on Trammel Creek, and two during 1917, while making investigations for oil companies.

Acknowledgments

The writer in the preparation of this report is indebted to two previous reports dealing with the oil industry in Allen County: one by Edward Orton: "Petroleum, Natural Gas and Asphalt Rock in Western Kentucky," issued by the Kentucky Geological Survey in 1891; and the other by Eugene Wesley Shaw and Kirtley F. Mather: "The Oil Fields of Allen County, Kentucky," Bulletin 688 of the U. S. G. S., issued in 1919. He has also had the advantages of advice and suggestions from Mr. Charles Butts of the U. S. G. S., who during part of the time was engaged in field work on the geology of the neighboring county, Barren. The writer's field assistant was Mr. Lafayette Herring, a student of geology at the University of Kentucky. The structure of the Gainesville oil pool as presented on the accompanying map was obtained from unpublished data, which will appear later as a separate paper.

Location, History and Geography

Allen County is situated midway along the southern boundary of Kentucky. It was organized in 1815 out of Warren and Barren counties and named in honor of Col. John Allen, a Kentuckian, who fell in the battle of the River Raisin. It is bounded on the north by Warren and Barren, on the east by Barren and Monroe, on the south by the State of Tennessee, and on the west by Simpson. The Barren River separates it from Warren in a winding course of 43 miles. Sulphur Fork of Middle Fork of Trammel Creek forms most of the boundary between it and Simpson. It contains an area of 394 square miles.

There are indications that previous to its settlement by whites, which began in 1797, it had at a remote period been occupied by rather permanent settlements of the aborigines. Traces of this occupation are much in evidence in various parts of the county. Within a big bend of Middle Fork of Trammel Creek, in the extreme western portion of the county, is a group of mounds surrounded by a rampart, which indicates that at one time here considerable preparation had been made for the defense of a community. Quite recently in the opposite section of the county the discovery of human bones, including a skull, associated with traces of pottery and basketry, has attracted considerable attention. The writer visited the scene of these discoveries, which is a large rockhouse formed by an overhanging cliff of Fort Payne limestone. It is on the Widow Devasher place and overlooks the Barren River toward the south. The bones had evidently been removed from what was originally a rough stone coffin formed on the sides of blocks of Fort Payne limestone and covered over with slabs of Chattanooga shale. The latter were obtained from an outcrop just below the floor of the rockhouse. The preservation of the bones is excellent on account of the deep recess under the overhanging cliff in which they were lodged. It is impossible that rain should ever have beaten in upon them. Since the writer finished his field work in the county, further excavation has brought to light other human bones (including skulls) in this rockhouse.

BURNING OIL TANK OF THE INDIAN REFINING COMPANY, SCOTTSVILLE.

This tank was set on fire by stroke of lightning the latter part of August, 1919. Out of 2,500 barrels of oil stored in it at the time, about 800 were saved by being drawn off into tank cars run upon a neighboring siding. Photograph by A. M. Miller. 1919.

Scottsville, the county seat, located somewhat south of the center of the county, was laid out in 1816. It had in 1910 a population of 1,400. The only other villages in the county are small, consisting of a few houses each. These, with their distances and directions from the county seat, are Gainesville, 7½ miles north; Holland, 9 miles southeast; Petroleum and Adolphus, the first 4 and the second 9.3 miles south; New Roe, 14 miles southwest; Mt. Aerial, 12.3 miles west; and Halfway, 7½ miles northwest. Other places, mere postoffices with a store, and in some instances two or three houses, are Meador, Yesse, Halifax and Cedar Springs in the northern part, Maynard, Godfrey, Amos, Forest Springs and Link in the eastern and southeastern part; Chapel Hill, Fleet, Alonzo, Pope, Clare, Trammel, Butlerville and Allen Springs in the southwestern and western part.

One railroad, a branch of the Louisville and Nashville, enters the county. It connects Scottsville with the main line at Gallatin, Tenn., 35.4 miles distant. About ten miles of this line is in Allen County. Scottsville is also on the Jackson Highway, which traverses the county from north to south, connecting it to the north in Barren

County with Glasgow and to the south in Tennessee with Gallatin. It is connected with Bowling Green, 24 miles distant, by a pike over which is maintained regular automobile service.

The other roads in the county are for the most part unimproved. Bridges over the streams are few, gradients steep, and surfaces rough. The system of road maintenance, as in most of the counties of Kentucky, is bad. During the summer season they can be traversed by automobiles, but at considerable cost for repairs.

Topography and Drainage

Allen County lies in a region of low relief, the range in elevation being from 444 to 942 feet above tide or a total of about 500 feet. The surface is rather rugged though not mountainous. A section across the main drainage streams will give a difference in elevation between valley floor and upland ridge of about 200 feet. In the northwestern portion of the county where there is a greater thickness of rather pure limestone (Warsaw and St. Louis) exposed, sinks are common and there is a considerable width of inter-stream areas without surface drainage. In the southeastern part where the impure limestone of the Fort Payne constitutes the main surface formation, small surface streams are multiplied and a more mature type of topography prevails.

All the county drains into the Barren River, which has a winding course for a distance of about 19 miles across the southeastern part, and as previously stated forms the boundary on the northeastern and northern part for 43 miles. The principal tributaries traversing the county are the following creeks: Puncheon, Long, Rodens (Roatens) and Walnut in the eastern part; Difficult and Little Difficult in the northern part; Bays Fork in the northwestern part; and Trammel and Middle Fork of Trammel in the southwestern part.

Geology

General Structural Features.—Allen County lies on the western slope of the Cincinnati Arch. This Arch has two culminating points or domes, the Jessamine and the Rutherford, the one in the Blue Grass Region of Kentucky and the other in a similar region in Tennessee. Lying on the west flank of a saddle between these two domes, but nearer the Rutherford than the Jessamine, this county has the prevailing dip of its rocks toward the northwest. The direction of dip varies from N. 30 degrees W. to N. 64 degrees W., and the general rate from 30 to 43 feet per mile. The steepest general dip seems to be in the northeastern portion where the rate varies between 33 and 43 feet per mile. A consequence of this prevailing dip toward the northwest is that in passing from southeastern to northwestern portion of the county, higher and higher formations are encountered at the surface. Upon this gently sloping flank of a broad arch are superimposed certain minor flexures with much steeper dips. Some of these, measured by plane table survey, are as great as 350 feet per mile. About 200 feet per mile is a common slope in these minor structures. In linear extent these slopes are usually from 1½ to 2 miles and in width about 1 mile. One—the Gainesville—is about 3 miles in length by 2½ miles in width. They are slightly elongated domes, the longer axes being generally parallel to the general strike of the rocks—that is from northeast to southwest. An enumeration of these domes is made in the discussion of the oil pools of the county in the latter part of this report.

Stratigraphy

Sytem	Series	Stage	Sub-stage		Thickness in Feet
Mississippian	Mammoth Cave	St. Louis			50
	Waverlian	Warsaw			100
		Fort Payne (Cuyahoga including New Providence)			200
		Kinderhook	Chattanooga	Sunbury Ohio	40-60
Devonian	Mid-Devonian	Genesee			
		Hamilton	Beechwood		2-5
Silurian	Niagaran	Niagara	Louisville Waldron Laurel Osgood		60

Niagara Limestone.—The lowest formation exposed in the county and the one which appears to be the chief oil bearing horizon, is a series of massive magnesian limestones with some shale, which from the contained fossils can be identified as of Niagara age. This formation outcrops along the Barren River and its main tributaries from the mouth of Walnut Creek nearly to the Monroe line. The exposure extends up Rodens Creek about two miles, all the way up Long Creek into Tennessee, up Hungry Branch 2½ miles, up Lick Branch 3¾ miles, up Puncheon Creek into Tennessee, and up Trace Branch about 1 mile. In the more southerly situations on these tributaries exposures attain a thickness of 60 feet. There is also an isolated exposure with a maximum of about 15 feet thickness on Trammel Creek near the home of Dr. Cook, and another further up the creek at

the Tennessee line. The combined areal outcrop of the whole formation is about 8 square miles.

Both the fossils and the lithological characteristics of the rocks indicate that the Silurian in the county is represented by the Niagara ranging from the Osgood to the Louisville inclusive. The writer has found at the Napier Ford on Long Creek in the lower rocks there exposed the Osgood trilobite *Bumastus ioxus* and the orthoceratite *Dawsonoceras annulatum.* (See Geology of Kentucky, plate 31, fig. 15.) In the upper beds he found *Conchidium nysium,* and *Atrypa reticularis niagarensis.* (Ibid, plate 33, figs. 44 and 45, and 1 and 2.) At the Barren River exposure east of Holland occur in the upper bed—that immediately underneath the Chattanooga shale—the following characteristic Louisville limestone fossil corals: *Cladopora reticulata, Halysites catenulatus* and a *Thecia* (probably *T. major*) (Ibid, plate 31, fig. 3 and plate 32, figs. 6 and 10). In the Trammel Creek exposure near Dr. Cook's place were found traces of some of these same corals and also a *Conchidium.*

Further up Trammel Creek at the State line, from fossils collected by Kirtley F. Mather, E. O. Ulrich identified the brachiopod *Pentamerus oblongus* (See *P. "cylindrica"* (*cylindricus*) Geology of Kentucky, plate 33, figs. 59 and 60).

On account of their durability—being magnesian and in massive ledges—these Niagara limestones tend to be cliff-forming. Due to variability in texture and composition they are apt to become much pitted on exposure. On the Barren River near Holland and on upper Long Creek the pitted and "clifty" character of these limestones is especially well exhibited. At the bridge over Barren River, on the Scottsville-Holland-Fountain Run pike about 35 feet of Niagara limestone rising in a vertical cliff from the river level is seen. The exposure is continued up the pike toward Holland until in all 60 feet of the rock are laid bare.

Delaware (Sellersburg) Limestone.—The Devonian in Allen County consists of a few feet of limestone and an undetermined portion of the overlying black shale —the Ohio shale part of the Chattanooga.

The limestone portion is thin—not over five feet in thickness. It has been identified only along the Barren River at the mouth of Rodens Creek, and at the Shallow Ford, the one next above the mouth of Dry Creek, a stream emptying into the river from the Barren County side. It is here a crinoidal limestone containing lenticular patches of sandstone.

Some of the crinoid stems in it belong probably to a species of *Dolatocrinus.* A very conspicuous and characteristic crinoid plate at this horizon is one with three equidistant, lateral, spinous processes. These must have formed when joined together a stem with three equidistant flanges. By means of this fossil fragment this horizon can be identified at every exposure in counties to the north (Adair, Marion, Nelson), connecting up finally with the top member of the Delaware in Jefferson County—that named the *Beechwood* by Mr. Charles Butts. This limestone is of Hamilton age.

The writer has been able to find no trace of the Onondaga (so-called "Corniferous," or Irvine sand of the oil well driller) in outcrop in Allen County, and doubts if any exists there even under cover, though just over the line in the Moulder pool of Warren County a Devonian fossil in a fragment of the oil rock, blown out in shooting a well, proves the presence there of Devonian limestone as the oil horizon.

Chattanooga Shale.—The shale portion of the Devonian—*Ohio shale* of more northern localities—is combined with the *Sunbury shale* of the overlying Mississippian to form the "Black shale" of this region. This *Chattanooga shale* is black, bituminous and fissile. Plant remains are found in it in the form of spores (*Sporangites huronensis*) and occasionally masses of silicified wood belonging to a species of Cordiates—*Callixylon* (*Dadoxylon*) *oweni* occur. One mass of the latter weighing about 300 pounds was found in Snake Creek, where it had washed out of the black shale exposure on that creek. As not more than ten feet of the top of the formation is exposed there it would appear that this species is likely a Mississippian rather than a Devonian form, as heretofore described. Among brachiopods two lingulas are known

from this formation in Allen County—L. *subspatulata a* Devonian form from the lower part and *L. melie* a Mississippian form from the upper part of the shale.

The outcrop of the Chattanooga shale, beginning at the bridge over Barren River where the Scottsville-Glasgow pike crosses, extends up the river nearly to the Monroe line and also up the same tributaries as does the Niagara outcrop. It of course extends further up on the sides of the valleys and nearer to the heads of the streams than does the Niagara. Isolated outcrops also occur in the southern part of the county as follows:

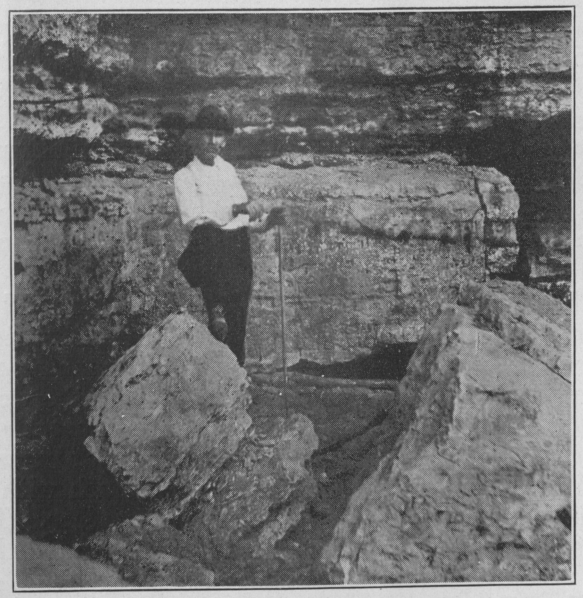
(1) On main Trammel Creek three patches; one beginning a short distance above the mouth of Ramble Creek, a second at the mouth of Rough Creek, and a third beginning about three-fourths of a mile above the mouth of Snake Creek. The last extends up the creek beyond where it is crossed by the Tennessee line. (2) On little Trammel Creek there are two patches; one at Petroleum and the other between that village and Adolphus. (3) There are also three other small patches; one on Rough Creek and two on Snake Creek. These exposures are accounted for mainly as the result of streams trenching domes, though Shaw and Mather suggest that the one (there are really two) on Snake Creek might be due to a continuous dipping bed which has been cut into at one place only in the path of a stream with a normal concave gradient. The combined outcrops of all the Black shale areas in the county aggregate about 12 square miles.

In outcrop the thickness of this formation ranges from 35 to 60 feet—the latter measurement being obtained at the Barren River bridge exposure east of Holland. Well records give a somewhat greater range for the thickness—22 to 70 feet. An average is about 45 feet.

FORT PAYNE CHERT.—This formation—named from Fort Payne, Alabama, and the prevalence of chert (impure flint) in it—has been traced into the county from its Tennessee outcrop. In the opinion of the writer it is the equivalent of the Cuyahoga of Ohio. In general it consists of about 200 feet of rather fine grained siliceous limestones interbedded with drab, limy shales, so-called "bastard limestone." Large crinoid stems are rather

DIPPING FORT PAYNE CHERT.

While resembling somewhat the flank of an anticline this is "false structure," the dip being due to original deposition not to subsequent tilting. West Fork of Bays Creek, near railroad trestle, Scottsville. Photograph by A. M. Miller. 1919.



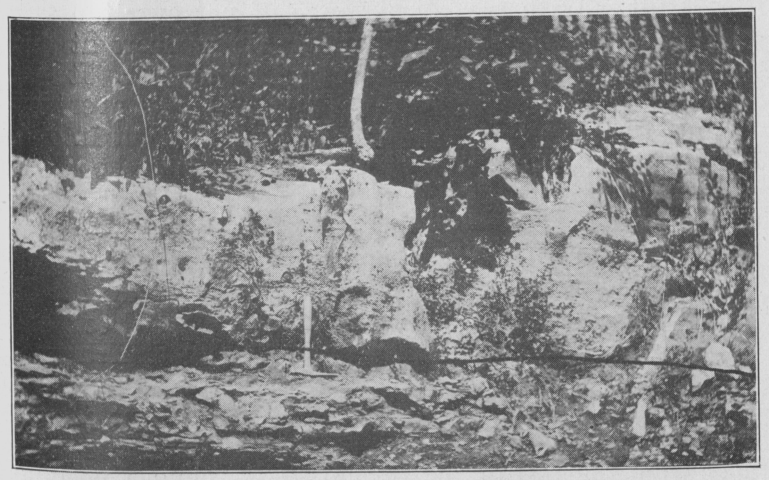
ROCK HOUSE IN LOWER FORT PAYNE CHERT, BEAVER CREEK OIL AND PHASE.

It was under this cliff overlooking the Parren River that Indian skeletons accompanied by pottery were recently found. Widow Devasher Farm, one and one-half miles northeast of Maynard. Photograph by A. M. Miller. 1919.

common in the limestones. Near the base of the formation a green shale with calcareous layers rich in crinoid stems occurs in a few places. This phase, so common at the base of the Cuyahoga in more northern situations (New Providence of Indiana, Raccoon of Ohio), is only occasional in southern Kentucky. It carries a typical New Providence fossil fauna which includes the coral *Cyathaxonia cynodon,* the brachiopods *Rhipidomella oweni* and *Chonetes shumardanus,* and the bryozoan *Cystodictya lineata* (see Geology of Kentucky, plate 54, figs. 25 and 26, 34-36, 10-12, and 1-2). It also carries another cup coral, very much curved, identified as *Zaphrentis cannonensis.* Cross bedding or false bedding is a very common feature of the lower part of the Fort Payne. The vertical succession in the layers varies much even in contiguous sections. In one place horizontal, typical "New Providence" shale may be seen abutting against highly inclined limestone of the more usual Fort Payne type, or the same relation may exist between successive beds of typical Fort Payne limestone; yet a short distance away the succession and attitude of the beds may be entirely different. Good places to see the features here described are in the railroad cuts between Petroleum and Adolphus. In other parts of the county, as on Barren River in the stretch directly east of Scottsville, very massive limestone occurs at the base of the Fort Payne. This has all the appearance of the rock which under cover constitutes the Beaver oil sand of Wayne County.

The siliceous matter in the form of chert and geodes, which is distributed throughout this formation, is of secondary origin. The segregation of the material along joint planes and its greater abundance in the weathered layers are proofs of this. If nodular masses of chert projecting from the joint face of a layer of limestone be hit with a hammer, they will scale off flush with the exposed face, leaving a clean limestone surface. There is no indication that the nodules ever penetrated the limestone as an original part of it.

The Fort Payne has the greatest areal exposure of any other formation in the county, constituting the surface outcrop over about 215 square miles. It forms with the exception of a small patch of Warsaw between Flatwood schoolhouse and Fountain Run the exclusive surface rock of the uplands lying east of Long Creek. Another considerable area lies in the upper portion of the Trammel Creek drainage in the southern part of the county. To the northwest, the outcrops of this formation, dipping down stream faster than the fall of the streams, become more and more narrow until, on Barren River and lower Bays Fork in the extreme northwestern portion, they disappear entirely by sinking below drainage. The formation on account of its highly siliceous character gives rise by decay to very cherty soils low in natural fertility.



WARSAW—FORT PAYNE CONTACT.

The massive basal layer of the Warsaw is filled with **Spirifer lateralis** Charles Potts Farm, Smyrna Creek, near New Roe. Photograph by A. M. Miller. 1919.

WARSAW LIMESTONE.—Overlying the Fort Payne is a formation about 100 feet thick consisting in the main of massive, crystalline limestone. Its prevailing color is blue. The crystalline character is due to its being composed largely of crinoid remains. Fragments of crinoids exhibit the rhombohedral crystalline cleavage of calcite better than those of any other type of fossil.

Interbedded with this limestone are some shale beds closely resembling those of the underlying Fort Payne. The chert formed by the weathering of the Warsaw also

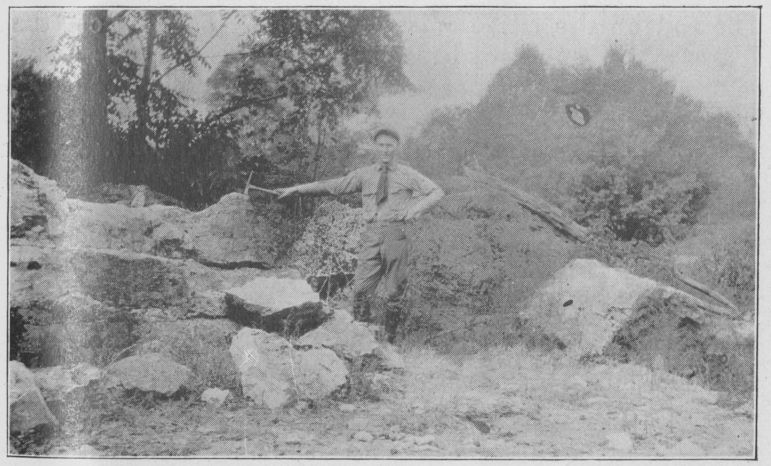
resembles that formed from the Fort Payne. The presence of brachiopods in considerable number and variety and the absence of large stemmed crinoids is characteristic of this formation in this and adjacent counties. It has an areal outcrop of about 133 square miles.

Especially diagnostic of this formation are the following fossil species—the blastid, *Pentremites conoideus,* and the brachiopods, *Productus magnus, Rhipidomella dubia, Spirifer washingtonensis,* and *Spirifer lateralis* (See Geology of Kentucky, plate 57, figs. 20-25, and plate 56, figs. 12-13; 4-6, and for *S. lateralis,* figs. 27-29.) The latter is especially characteristic of the base of the formation. With a vertical range of not over ten feet, and always present in considerable numbers at this, horizon, it serves as a reliable horizon marker. It may be recognized from any other spirifer by its great extension of hinge line, the shell being drawn out into attenuated points laterally like a waxed moustache.

The Warsaw, where not itself covered by the waste of the next overlying formation—the St. Louis—covers the uplands to the west and north of Scottsville. A tongue of it also extends southeast of Scottsville along the divide between the east and west forks of Bays Creek, and between Long Creek and the waters of upper Trammel.

The soil formed from the Warsaw is red. It excels in natural fertility that formed from the Fort Payne, though like the latter it is quite cherty. In the weathered products from the top of the formation is found a peculiar type of geode, lined on the inside with a chalcedony having a stalactitic structure.

St. Louis Limestone.—This, the highest formation in the county, is represented, where present, by a heavy deposit of chert waste. A conspicuous element of this is a nodular flint. Much of the latter is spherical in form, and resembles croquet balls. Mingled with the latter, silicified masses of the hornet's nest like coral—*Lithostrotion basaltiforme*—and of *Lithostrotion proliferum* are common.



LOUISVILLE LIMESTONE BED OF THE NIAGARA FORMATION.
Trammel Creek exposure, Gibson Howell Farm, six and one-half miles south of Scottsville. Photograph by A. M. Miller. 1919.

On the areal geology map accompanying this report, areas are represented as St. Louis, where either or both of these two fossils could be found in the chert waste. Three such areas are found in the northwestern portion of the county; one covering the divide between Difficult and Little Difficult Creeks, a second that between these two creeks and Sulphur Fork of Bays Creek and extending around the head of Sulphur Fork on to the divide between the latter and Bays Fork; and a third along the line of the Scottsville and Bowling Green pike on the divide between Bays Fork and Trammel Creek. This exposure does not extend east of the crossing of this pike with the old state road. West of Trammel Creek five separated patches are represented on the map as St. Louis where no Lithostrotion could be found in the chert waste, but where the interval between the base of the Warsaw and the top of the ridges was more than a hundred feet, and therefore, too great to be filled entirely with Warsaw outcrop. The combined areal outcrop of the formation is about 25 square miles.

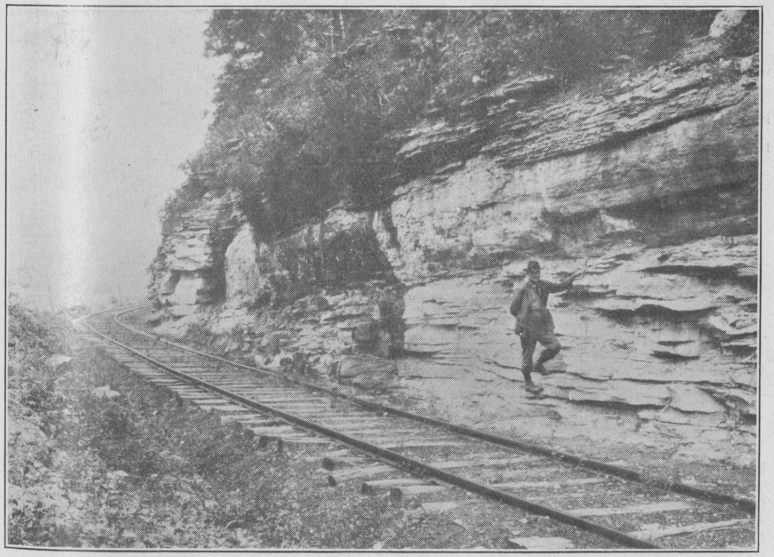
The St. Louis outcrop is characterized by sinks. These extend down into the underlying Warsaw. Sometimes the throat of these becomes clogged so they will hold water and then are utilized as stock water ponds.

The soil on the St. Louis is similar to that on the Warsaw. No outcrops of undecomposed St. Louis could be discovered, and hence no exact measurements could be made to determine its thickness in the county. An estimated thickness of 50 feet is here assigned to it.

Economic Geology

Petroleum—The chief economic mineral product now btained in Allen Cunty is petroleum. The early discovery of this product here, as in other regions of the state, was intimately associated with the salt industry. The manufacture of salt from brine obtained from wells was carried on rather extensively in the early days of the county. It reached its maximum about 1848, when as high as 300 bushels of salt per week were produced. The center of the industry was at Port Oliver, a place on the Barren River, eleven miles north of Scottsville. The salt was shipped out mainly by barge on the river. The brine used in the manufacture was obtained from drilled wells and evaporated in large iron kettles. A number of these kettles are still in existence in various places in this and adjacent counties, where they are commonly used as receptacles for stock water. In the course of exploration for salt water, oil was frequently struck. There was no demand for this except as a medicine and for "greasing hogs." Oil was also obtained for these purposes from oil springs. Two of these were especially resorted to, one on Main Trammel and the other on Little Trammel Creek. The former, when referred to by Professor Orton, in his report previously cited (page 1), was on the land of A. S. Walker, near where the Scottsville-Franklin pike crosses the creek. The writer visited this spring in the summer of 1896. It then had an accumulation of oil on it sufficient, when ignited, to burn with a flame that extended to the tree tops. When he revisited the locality during the past summer he was unable to find this spring. Professor Orton reported that a barrel of oil was collected from this spring in 1850 by Younglove Brothers, druggists of Bowling Green, and shipped to Pittsburg to be prepared there for medicinal purposes.

It was the presence of the oil spring on Little Trammel Creek, near Petroleum, which led to the drilling for oil there when the region was occupied by the Confederate Army during the Civil War. The product was shipped to Memphis.

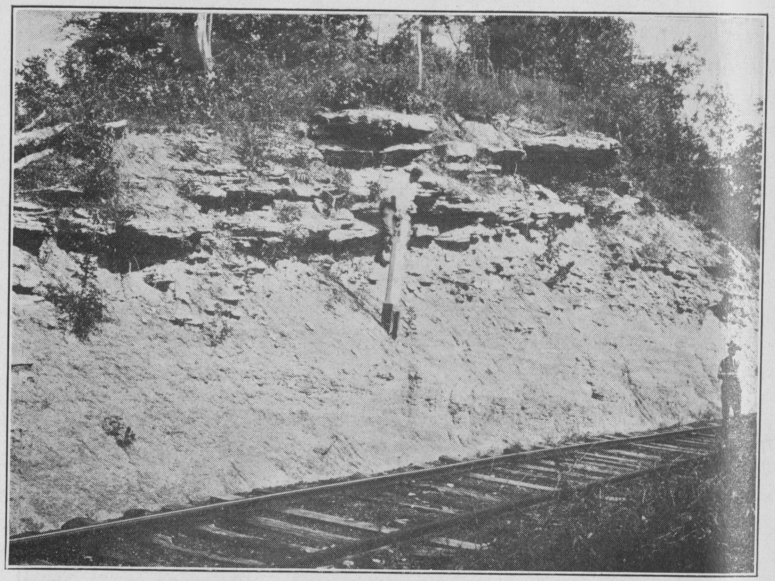


CONTEMPORANEOUS UNCONFORMITY IN LOWER FORT PAYNE.

The contact indicated by the position of the hammer is between beds at the New Providence horizon.

Cut on the Gallatin—Scottsville branch of the Louisville and Nashville Railroad about one mile south of Petroleum. Photograph by Charles Butts.

With the resumption of oil development at the close of the Civil War, attention was naturally directed to Allen County, and much prospecting and some drilling were done in the vicinity of these two oil springs and the old salt wells. The persons interested in this attempted development were mostly northern men, who as soldiers had campaigned through the region during the war. The most successful of the wells during this period was the one drilled in 1866 known as the "Porter Well," located on the Uriah Porter farm situated in the forks of Bays Creek. This land is now owned by A. J. Willoughby. The drilling was done by Mr. Porter and his sons. No reliable information can be obtained as to the exact depth of the



CONTEMPORANEOUS UNCONFORMITY IN LOWER FORT PAYNE.

Horizontal layers of typical New Providence shale are here overlaid by inclined layers of limestone such as is usually found in the Fort Payne. The difference in dip between the two beds shown in this and the preceding illustration is interpreted by the author as due to alternate deposition and erosion during a rather continuous depositional period rather than to such alternation separated by crustal movements the resultant of which was the tilting of the upper bed.

This exposure is practically continuous with the one shown in the preceding illustration. Photograph by Charles Butts.

well. The figures given for the depth vary from 70 to 300 feet. The well flowed for a time and yielded a highly sulphurous oil, which was estimated in quantity at about 500 barrels per day.

The oil did not find a ready sale at the refinery in Louisville, to which it was shipped, as with the crude methods of refining then in vogue, the sulphur could not be readily eliminated. Professor Orton, who has preserved for us the account of this enterprise, thought the oil must have come from the Keokuk. There appears no reason, however, why it should not have come from the same horizon (Niagara limestone) as yields oil now in neighboring wells. Another well was drilled in the spring of 1866 further down Bays Fork, on what was then the Abram Jones place, but which now belongs to H. T. Motley. This well is reported to have been 300 feet deep.

Oil collected in it, but did not flow over the top. Professor Orton refers to other wells drilled in the vicinity of these, all of which were unsuccessful. One drilled on the Ham farm one mile above the Porter well struck gas in sufficient volume and force to throw the tools out of the well.

When the next wave of oil and gas excitement swept the State in 1887, Allen County again received attention from the driller, and a number of wells were put down—some of them to a considerable depth. The deeper drilling was done with the expectation of striking oil or gas in the Trenton limestone—the new horizon which had proven to be so productive in northern Ohio and Indiana. One of these reached a depth of 1,300 feet, passing completely through the Trenton formation. This well was located near the site of the Old Porter well, the farm at that time having passed into the hands of Col. E. L. Motley of Bowling Green. Also in 1903, when an oil excitement caused by the discovery of the Ragland pool again swept the State, drilling began anew in Allen County and some deep wells were put down. One of these, according to Shaw and Mather, drilled by a Franklin company near the site of the oil spring on Trammel Creek, reached a depth of 1,389 feet.

At a depth of 288 feet, at the same horizon from which the other wells in the county now draw their supply, a small amount of oil was struck, but nothing was obtained at any deeper horizon. This well also penetrated the Trenton limestone.

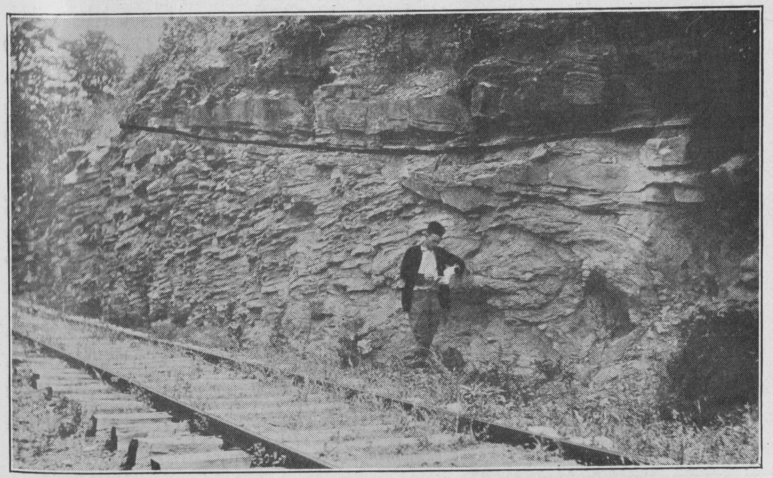
The present oil development in Kentucky, beginning with the successful well by Charles Dulin on Tick Fork of Cow Creek, Estill County, in 1915, made itself felt in Allen and resulted in about 130 wells being put down in the county in 1916. Some drilling had been done in the few years preceding this, but it had been of a desultory character. Most of this drilling was done in the region to the south of Scottsville, where wells with an initial production of from 30 to 35 barrels per day were struck. The drilling continued into 1917 when the Rodemer pool was discovered. According to the Oil and Gas Journal for March 29, 1917, as quoted by Shaw and Mather, there had then been drilled in the county in the recent develop-

ment 138 wells, 102 of which were producers. These wells were then estimated as having a combined production of 1,434 barrels per day. At the time (May, 1917) when Bulletin 688, U. S. G. S., was prepared by Messrs. Shaw and Mather, they recognized seven pools as having been discovered in the county. These, all south of Scottsville, were named in order southward: Scottsville, Rodemer, Wildwood (Reeves-Fisher), Turlock (Miller), North Petroleum, Petroleum and South Petroleum. To these should have been added the Adolphus. At the time the report was published the Gainesville pool had been discovered by the bringing in of the Moore and Johnson wells, but the full significance of the discovery was not at that time apparent.

This Gainesville pool has since proven itself to be the most extensive single pool yet discovered in the county. At present writing some 360 wells have been drilled in it ranging in depth from 190 to 520 feet, with an average depth of about 350 feet. The top of the sand is usually about 20 feet below the base of the Black shale and is probably Niagaran. All but about 75 of the wells have proven to be good producers. The best lease on the pool is a tract of about 100 acres known as the "Andy Smith lease." Out of 25 wells drilled on it 24 are oil wells and one yields gas. Latest reports indicate the twenty-four wells had a combined production of 750 barrels per week. The range in initial production per well for this pool as a whole is from 25 to 150 barrels per day, with 50 barrels as the average. The output goes over two pipe lines, one to Scottsville and the other to Bowling Green, whence it is shipped by rail to the refineries. A plane table survey of this pool by Hudnall shows that it covers a dome about 2½x3 miles in diameter and, as measured on the top of the Black shale, ranges from the 350-foot contour at the base, to the 450-foot contour at the apex. The occurrence of gas, oil and salt water on it follows theory strictly —gas at the top, oil on the flank, and salt water at the bottom.

The other pools discovered since the Shaw-Mather report was published, with their distances and directions from Scottsville, are as follows: Merideth, 6 miles northwest; Oliver, 7 miles northwest; Costello, 1½ miles southwest; Wheat, 6½ miles southwest; McReynolds, 4 miles southwest; Dalton, 3¼ miles south; and Taylor School, 5 miles southwest.

In all the pools of Allen County drilling is shallow, ranging from 70 to 520 feet. In the region to the south of Scottsville wells are seldom sunk to a greater depth than 300 feet. Usually they range from 200 to 250 feet. In this district three pays are known, all Niagaran, distributed through an interval of 165 feet below the Black shale. In most cases there is only one pay and the top of it is usually within 50 feet of the base of the shale. Sometimes only a "caprock," a few feet in thickness, intervenes between the "shale" and the "sand." The "sand" or the "pay sand" seldom exceeds 15 feet in thickness—more often it is from 5 to 10 feet.



LOWER FORT PAYNE CHERT

Showing deceptive unconformity due to variations in velocity and direction of the currents in which the strata were laid down. Railroad cut one mile south of Petroleum. Photograph by A. M. Miller, 1919.

It is difficult to estimate the total number of wells which have been drilled in the county. Those put down during past periods of oil excitement have been largely forgotten. Even in regard to the drilling which has taken place since the last boom struck the county it is not easy to get a complete record. A number have been drilled by individuals or small companies, who were unsuccess-

ful and left the field; and in any event a dry hole is hard to locate, for a farmer is rather loth to admit that any such have been drilled on his land. Also the quickness with which a well can be drilled (five days is generally long enough to put one down), tends to their effacement from memory, if they were dry or did not keep up their production long. From statistics compiled by Shaw and Mather for the three years from 1916 to 1918 inclusive, out of a total of 511 wells drilled 75 per cent were productive. The average initial daily production for this 75 per cent was 40.4 barrels. The total annual production for the year 1917 was 100,000 barrels. On the map accompanying the present report 975 wells are located. This is possibly not over two-thirds of all the wells that have been drilled in the county. About 790 of these are within a north and south belt about five miles wide with Scottsville situated on its eastern margin. A total of 210 of those plotted, or 21.5 per cent. are dry holes. One hundred and thirty-five of these are within the belt above mentioned. The remaining 75 are widely scattered over the rest of the county.

The amount of oil shipped from the county during the time the writer was carrying on his investigations in it was 67,000 barrels for July and 54,600 barrels for August.

The oil pools of Allen County are small, those south of Scottsville containing not over 1 to 2 square miles each. The Gainesville pool, in the northern part, is much the largest one in the county. It has an area of about seven square miles. So far as examined all the pools have been proven to be located on structure. Shaw and Mather called attention to five favorable structures (anticlines) in the county, which at the time their report was published had not been tested. These are as follows: (1) One northwest of Scottsville, crossing Bays Fork about two miles from the town; (2) one east of Scottsville, crossing Bays Fork of Bays Creek where the latter is crossed by the road to Maynard; (3) the Petroleum anticline, extending east-northeast from Petroleum; (4) Rough Creek anticline, traversed by Rough Creek 2 miles from the mouth; (5) Trammel anticline, crossing Trammel Creek between the mouth of Snake Creek and the Tennessee line.

The *first* of these is at present being tested, and several wells showing small production have been obtained on it. The *second* has been proven to yield gas. The best gas well yet struck in the county—the one on the Price Turner farm—is in the line of this structure. The *third* has been tested on the south side and a number of good producing wells have been struck in relation to it, but pretty far down into the syncline. This is the Taylor School pool, now being developed. The *fourth* has been tested without favorable results. The *fifth* has exposed on its crest the top of the oil sand and hence does not invite exploration for oil.

The eastern part of the county—that portion east of a north and south line through Scottsville—lies in territory which may be set down as barren of oil. The rise of the strata in this direction brings the oil sand near to the surface and along the main drainage streams even exposes it to view. East of Long Creek, especially, there has been no chance for any great amount of oil to have accumulated, as the trenching of the sand by that creek on the down dip side must have effectually prevented oil from working up the dip slope into this extreme southeastern part of the county. In the same way the Barren River trench has cut off oil from the portion of the county lying east of that stream.

West of a belt about five miles wide extending north and south, with Scottsville at its eastern margin, there remains considerable territory which has as yet not received sufficient exploration by the drill. It seems rasonable to expect that a number of pools may yet be discovered in that region.

Advisability of Deep Drilling.—A number of wells in the county, some of them already referred to, have been sunk to and even below the Trenton limestone. Not a trace of oil has been found at these greater depths. Once the Niagara formation is penetrated the limestones become hard and compact and the drill reveals only a monotonous succession of rocks totally unfit to become reservoirs for oil or gas. Two deep wells, to which refer-

ence has been made, have been drilled—one 1,300 and the other 1,389 feet deep. During the recent development at least three other deep wells have been drilled—one by the Long Creek Oil Company on Long Creek west of Holland, 750 feet deep; a second at Harmony school in the western part of the county, 1,262 feet deep; and third, one and one-fourth miles northwest of the latter, 500 feet deep. The last two were drilled by the Carter Oil Company.

In the light of what is known concerning the non-petroliferous character of these underlying formations in this region, as revealed by deep well drilling, further exploration of this character is not to be recommended.

THE PAINT CREEK UPLIFT

By E. O. Rhodes

Consulting Geologist, Lexington, Kentucky.

Introduction

In the early spring of 1917, the writer spent three months in Johnson and Magoffin Counties, Ky., making an investigation of the oil and gas possibilities of the area which is now known as the Paint Creek Uplift. This report is the outcome of three months' careful examination of the exposed rocks and the structural conditions of that portion of Johnson and Magoffin counties shown on the accompanying map. The writer began this investigation with a view of determining whether or not the Irvine Fault extended into Johnson County. The uplift had been previously mentioned in several reports of the Kentucky Geological Survey, but all available data at that time failed to show whether or not the Irvine Fault extended through this area.

Location

The Paint Creek Uplift which the writer has definitely determined to be a continuation of the Irvine Fault, enters Johnson County at the mouth of Lacey Creek, extending in a general east-west direction to the mouth of Brush Fork of Tom's Creek. Beyond this locality the beds which dip eastward have flattened and broadened to such an extent that the fold cannot be recognized, although it is quite probable the fault continues eastward. The structure is approximately in the central part of the county and extends from the western edge to its center. If prolonged, the trace of the fault would pass about four miles north of Paintsville. The uplift affects the territory for a distance of at least five miles both north and south of the fault.

Topography and Drainage

There are two types of topography developed in the area of the Paint Creek Uplift. One has its topographic features formed by the Pottsville Conglomerate, the

other has its relief developed from the sands and shales above the conglomerate. Conglomerate topography consists of steep canyon walls with flat-topped uplands. Frequently perched on the plateau formed by the conglomerate, are low mounded hills formed from the upper Pottsville sandstones and shales. Well down the flanks of the uplift, where the conglomerate dips below the drainage, topographic forms, near the heads of the valleys, are steep hillsides and V-shaped valleys, though near the mouths of the larger streams the valleys have broadened by side cutting.

The major drainage unit of the area is Paint Creek which enters the Levisa Fork of the Big Sandy River at Paintsville. Paint Creek, where it enters the county, follows more or less the strike of the structure to the mouth of McKenzie Branch where it swings abruptly to a little east of south and cuts directly across the structure, making a large angle with the strike. At the mouth of Barnett's Creek, Paint Creek again swings eastward and follows in a general way the strike of the rocks to its mouth at Paintsville.

The principal tributaries of Paint Creek are Mine Fork, Barnett's Creek, Mud Lick Creek and Little Paint Creek. The secondary streams are: Little Mine Fork, which flows into Mine Fork above its junction with Little Paint Creek; Hargis Creek, Pigeon Creek and Davis Creek which empty their waters into Little Paint Creek. Pickel Fork and Tiny Branch flow into Barnett's Creek; while Lowgap Branch, McKenzie Branch and Calvin Branch flow directly into Paint Creek. There are a number of tributaries to Tom's Creek, the most important of which are Sycamore Fork and Rush Fork. Tom's Creek enters the Big Sandy River above Paintsville.

Stratigraphy

The rocks exposed by the Paint Creek Uplift extend from the carbonaceous shales below the Pottsville Conglomerate up through the Pottsville formation into the Allegheny formation. The Pottsville Conglomerate and the shales beneath the conglomerate are exposed on the north side of the fault. On the south side of the fault only

STRUCTURE MAP
OF THE
PAINT CREEK UPLIFT
IN
JOHNSON COUNTY, KENTUCKY.
SCALE IN MILES
0 3/4 1 1/2 2 1/4
CONTOUR INTERVAL 10 FEET.
DATUM SEA LEVEL.
BY
E.O. RHODES & K.D. WHITE,
LEXINGTON-KENTUCKY.
MAY-1917
NOTE: ⟶ = Dip.
STRUCTURE CONTOURES BASED ON ANEROID ELEVATIONS ON TOP OF POTTSVILLE-CONGLOMERATE.
LEGEND
Oil
Oil & Gas
Gas
Drilling
Dry
Location
OPHIR
EDNA DAIN
FUGET
KENWOOD
VOLGA
MANILA
STAFFORDSVILLE
STAMBAUGH
NIPPA
MINGO
OFFUTT
WILLIAMSPORT
PAINTSVILLE
MUD LICK
TOMS CREEK
RUSH FORK
PAINT CREEK
BIG SANDY RIVER
LEVISA FORK OF THE
FAULT
Oil Seepage
Good Oil Showing
MORGAN COUNTY
JOHNSON COUNTY
N.
S.
W.
E.

the upper part of the Pottsville Conglomerate is exposed. The rocks dip both to the north and to the south from the axis of the fold and the conglomerate goes rapidly below drainage. The sharpness of the dip caused the conglomerate to be exposed only on the highest parts of the structures, the flanks of the fold having the surface rocks composed of sandstones and shales of the upper part of the Pottsville formation and the lower part of the Allegheny formation.

The Pottsville formation thickens rapidly from the north towards the south. In Carter County the conglomerate rests directly upon the Mississippian Limestone, while on Little Mine Fork 90 feet of shales are exposed beneath the base of the conglomerate, and according to report, one of the wells drilled on the edge of the uplift found 400 feet of shales between the base of the conglomerate and the Mississippian Limestone.

Structure

The accompanying map shows approximately the structure of the Paint Creek Uplift in Johnson County for a short distance on each side of the fault. The structure contours are based on aneroid elevations at the top of the Pottsville Conglomerate. Changes in structure are so rapid and the dip of the rocks so sharp that anything other than very detailed mapping on a large scale would give only a general idea of the structure.

The principal structural feature is a fault which the writer traced from Mine Fork at the western edge of Johnson County to Slate Branch in the center of the county. The distance is about 9 miles. The fault is very pronounced and easy to follow as far as Mud Lick Creek; beyond Mud Lick Creek it is difficult to recognize. The location of the fault plane on Slate Branch is only indicated by its effect on the topography. The amount of displacement could not be measured at this locality. On Little Mud Lick Creek no break could be found, the structure indicating that the fault apparently died out into a fold. In tracing the fault it was noted that there was a tendency for certain segments to follow an east-west direction. Where the segments were offset, an echelon with

cross-segments connecting them. The cross-segments intersect the east-west fractures at a low angle. There was also noted a tendency of the rocks, especially on the north side of the fault, to dome at the intersection of these segments. The faulting is normal, the upthrow being to the north. The displacement among the fault plane from Mine Fork to where the fault crosses Paint Creek averages about 120 feet. The throw varies slightly from this amount between these locations, being a little more at some places and a little less at others, but the variations are small. East of Paint Creek the amount of throw rapidly decreases to Mud Lick Creek where it is only 45 feet; east of Mud Lick Creek the amount of throw is so small before it reaches Little Mud Lick Creek that it cannot be recognized on that stream. Though the amount of the throw of the fault does not begin to decrease until east of Paint Creek, the formations that it cuts slope eastward from Mine Fork. Several domes occur between Mine Fork and Paint Creek, but each one to the east is lower than the one to the west.

The structures south of the fault are very irregular and most of the domes or structurally high spots occur with well marked synclines or troughs between. The most pronounced of these features is the syncline about a half mile south of the fault that extends from Mine Fork to Paint Creek. The syncline is well developed between these localities though it cannot be traced east of Paint Creek, where it ends very abruptly. It appears to come in about a mile south and extends to Mud Lick Creek beyond which it apparently merges into the general structure of the Sitka Nose.

On the head waters of a branch of Ticklick Creek that heads in the high country between Little Mine Fork, Hargis Creek and itself, a dome occurs which is the largest and most pronounced of any of the structures south of the fault. It has an elevation of 120 feet above the syncline to the north and a drop to the south of at least 90 feet and to the east of not less than 150 feet.

On Little Paint Creek there is apparently developed a broad synclinal trough extending from the mouth of Pigeon Creek southward to Pound Mill Branch, eastward well up Davis Branch and westward to Pigeon Creek.

Sufficient data to indicate the size and shape of this trough were not collected, so that its relation to the sharp syncline on Calvin Branch is not known, but it is probably a widening of the same trough. At Manila at the mouth of Calvin's Branch this syncline is well developed, but plays out to the east into an eastward dipping monocline. Just north of Manila the rocks rise 30 feet forming a small, sharp anticline and then plunge 110 feet northward to the fault plane.

On Mud Lick Creek there is a well developed syncline the axis of which extends westward to Paint Creek where it disappears. This syncline apparently does not connect with the syncline at Manila. North of this syncline on Mud Lick Creek the rocks rise sharply to the fault.

South of the syncline the formations rise 130 feet to a well defined fold at the mouth of Little Mud Lick Creek and then plunge southward at a very sharp dip for 100 or more feet. The dome just described is apparently the eastward extension of the nose putting off from the main structure between Davis Branch and Calvin Branch. The exact form and size of the nose was not determined.

North of the fault the structure is more regular and the dip at a lower angle. In the structure belt north of the fault there are four localities at which there are well developed northward plunging folds. They are located on Little Mine Fork, Hargis Creek, Paint Creek and Mud Lick Creek. The pitch of each fold is very sharp. The folds are well defined for at least a mile north of the fault.

On Mud Lick Creek the rocks dip northward from the dome which is just east of the creek, to a sharp synclinal, and then rise northward to a small dome, again to reverse their dip toward the syncline south of Flatgap. The small syncline on Mud Lick Creek apparently extends for a short distance only and probably merges rapidly eastward into the general structure of the Sitka Nose. Sufficient information was not collected to determine the relation of the structures just north of the fault with the region between the fault and the Laurel Creek Dome, but apparently the rocks dip in a general

northward direction to the syncline south of Flatgap, which separates the two structures.

The Sitka Nose may be termed the eastern end of the Paint Creek Uplift. The nose is a well-pronounced anticlinal fold pitching sharply to the east. The north, south and east limbs are well developed, but the western edge is not closed by a reversal dip. The nose is the result of an anticlinal fold replacing the fault at this point. On the east side of the nose the rocks dip eastward, at a decreasing angle to a low broad trough in which there are apparently no folds of consequence.

Possible Oil Horizons

On the structures of the Paint Creek Uplift there are three horizons that contain petroleum possibilities. They are the Big Injun Sand, the Berea Sand and the Irvine Sand. The Pottsville Sands are either at the surface or so close to it that any collection they may previously have held has been dissipated. On Tom's Creek several wells have been drilled; one drilled near Sitka is not shown on the map. The Tom's Creek wells give the average depth to the Big Injun Sand below the top of the Pottsville Conglomerate as about 600 feet; the depth to the Berea Sand below the same horizon is about 950 feet; while the average depth to the Irvine Sand "Corniferous Limestone" is about 1600 feet below the top of the Pottsville Conglomerate.

Petroleum Evidence and History of Early Development

A number of wells have been drilled around the edge of the structure and most of them have found either showings of oil or gas. The old well drilled at Manila on the Davis farm is located highest on the structure and nearest to the fault of any of the old wells. At the time of visiting, oil was standing within four feet of the top of the casing and a can lowered fifty feet into the well brought up only oil. The oil is a light green with a high gasoline content, of a gravity probably higher than 35 degrees Baume'. The well was reported to have been drilled ten years ago and to have reached a depth of 1,600 feet.

A prior well was drilled in the early seventies about six feet from the present well. What appears to be creditable authority reports that when the well was drilled in it threw oil over the top of the derrick. This oil probably came from the Irvine Sand. The same authority reports a light showing of gas in the Berea Sand in the recent well.

On Little Paint Creek a well was drilled ten years ago between two active oil seepages to a reported depth of 900 feet. The oil is reported to have been found at about 350 feet and gas at about 700 feet; the gas has been escaping since then, and is at present burning with a small flame a foot or two above the casing. The seepages near the well are of considerable size. They are probably coming from the Pottsville Conglomerate which is exposed in the cliff nearby; though it is possible that the oil may come to the surface from a deeper sand by a lateral fracture from the main fault. No evidence of faulting could be noted in the vicinity. The seepages consist of heavy, black oil. The oil comes to the surface associated with a considerable quantity of fresh chalybeate water. On the hillside below the spring, a considerable quantity of asphalt or brea has collected. There are two springs at this locality, either would probably make as much as a quarter of a barrel of oil a day if they were cleaned out.

At Ophir, a well is reported to have made a good showing of gas associated with fresh water.

On Little Paint Creek, near the mouth of Dry Branch, a well was drilled eight or ten years ago which is reported to have pumped from two to five barrels of oil per day for some time.

On Tom's Creek, a number of wells have been drilled, but the locations of all of them are not shown on the map. Some of the wells are reported to have made as much as twelve barrels per day. All the wells were far down the slope of the structure.

On Rush Fork, above the mouth of Sulphur Spring Branch, a well was drilled ten years ago. At present there is a strong ebullition of gas coming up through the water, though the well has been plugged. The well was drilled to a depth of 2,485 feet. When the well was

drilled in, the water is reported to have been thrown out sixty feet into the air. A strong flow of hydrogen sulphide is coming up through the water, which is suphurous. Most of the gas is probably methane; it burns readily.

At the mouth of Sycamore Creek there is a deep well with an artesian flow of water. The well started with a ten-inch casing, but its depth is unknown.

Recent Development

Since our previous examination of this territory a number of wells have been drilled on the uplift. The approximate locations of these wells are shown on the accompanying map. Most of the recent development has been carried on by the Midsouth Oil Company and the Bedrock Oil Company which are now actively engaged in drilling operations on the dome now commonly referred to as the Ticklick or Mine Fork Dome. The Bedrock Oil Company is now drilling its ninth well, while the Midsouth Oil Company is drilling number four. In all, eight or nine producing gas wells have been developed on this dome. These wells encountered gas at approximately 850 feet and are producing from what is termed the Weir Sand which is either just above the Berea Sand or possibly the top of the Berea. Most of these wells have an open flow of about two million cubic feet of gas per day with a rock pressure of about 275 pounds. The gas is now being marketed and prospects are that a number of wells will be completed on this dome during the summer of 1919. As there has been very little prospecting in the deeper sands it is very probable that the deeper sand will either show oil or gas. Most of the gas wells are located high on the structure and there is a strong probability that oil will be encountered at other favorable points along the uplift.

March 10, 1919.

THE AMOUNT OF STANDING TIMBER IN KENTUCKY.

By J. E. Barton

Commissioner of Geology & Forestry.

Requests are continually reaching this office for information in regard to the amount of standing timber in the whole State of Kentucky, in individual counties or by species with relation to State or county. Such information has not heretofore been widely available. Unfortunately, within the recent years, a sufficient sum has not been at the disposal of this department to complete a detailed and up-to-date estimate of the timber resources of the State. The only figures available date back some years and a large share of the removal of the timber within Kentucky, due to large operations, has taken place within a recent period. Nevertheless, the demand for some character of information in regard to the amount of standing timber is so insistent that the available figures are here published with the understanding that they represent a much larger stand for the State than actually exists on the ground at the present time. They are published at this time as a basis for comparison and it is safe to say that in most instances at least 25 per cent. of the indicated estimated stand of timber has been cut, since the compilation of the figures. It must be borne in mind, however, in this connection that the figures as here given were compiled under conditions which did not permit an extremely close and careful estimate and that experience heretofore has shown that estimates of standing timber usually fall considerably below the actual cut so that the statistics here presented are felt to approach within a reasonable degree of accuracy of present conditions. The estimate of standing timber presented at this time was completed under a co-operative agreement between the Forest Service of the U. S. Department of Agriculture, and the Commissioner of Agriculture, Forestry and Immigration of Kentucky.

STAND OF TIMBER IN KENTUCKY

Name of County	Total Area in Acres.	Area Forested Acres	Per Cent. of Forest.	Average Stand Per Acre Bd. Ft.	Total M. Ft. Bd. M.
Adair	231,680	108,347	47	1,477	160,143
Allen	273,920	85,230	31	1,122	95,662
Anderson	143,360	20,382	14	831	16,928
Ballard	151,680	39,272	26	1,258	49,417
Barren	313,600	99,891	32	1,779	177,750
Bath	172,800	69,089	40	1,107	76,899
Bell	226,160	184,811	82	5,616	1,037,824
Boone	154,880	7,031	5	255	1,796
Bourbon	170,880	5,126	3	1,600	8,202
Boyd	136,451	44,979	33	1,570	70,864
Boyle	102,400	14,253	14	550	7,833
Bracken	123,520	2,401	2	2,704	6,508
Breathitt	307,200	245,848	80	3,564	876,298
Breckinridge	380,800	66,765	18	661	44,049
Bullitt	192,640	87,767	46	709	62,261
Butler	261,760	129,215	49	746	96,383
Caldwell	216,320	71,377	33	1,810	137,259
Calloway	257,280	88,430	34	1,378	121,862
Campbell	92,800	1,752	2	2,421	4,241
Carlisle	120,320	41,731	35	1,821	75,999
Carroll	113,920	6,527	6	820	5,352
Carter	251,808	154,887	62	1,070	165,722
Casey	237,440	97,945	41	2,265	221,842
Christian	444,160	117,207	26	1,523	178,520
Clark	170,880	23,221	14	581	13,503
Clay	292,480	175,690	60	3,847	675,915
Cilnton	143,360	53,834	38	1,141	61,420
Crittenden	249,600	50,680	20	990	50,152
Cumberland	263,040	125,439	48	1,123	140,842
Daviess	283,200	113,723	40	1,940	220,593
Edmonson	166,400	91,220	55	606	55,302
Elliott	145,000	55,000	38	2,000	110,000
Estill	163,200	90,894	56	1,414	129,528
Fayette	172,160	5,614	3	1,123	6,305
Fleming	204,160	29,830	15	1,243	37,067
Floyd	254,664	165,305	65	3,690	610,880
Franklin	149,760	7,307	5	563	4,076
Fulton	113,920	33,948	30	2,175	73,820

Name of County	Total Area in Acres.	Area Forested Acres	Per Cent. of Forest.	Average Stand Per Acre Bd. Ft.	Total M. Ft. Bd. M.
Gallatin	67,840	2,381	4	306	729
Garrard	149,760	13,158	9	601	7,837
Grant	174,720	9,408	6	780	7,339
Graves	152,000	58,112	17	882	51,231
Grayson	336,000	88,052	26	854	75,186
Green	148,480	30,454	21	2,003	61,216
Greenup	204,216	115,680	57	1,290	149,794
Hancock	124,800	16,512	13	423	6,989
Hardin	394,240	51,642	13	727	37,551
Harlan	300,800	266,212	89	7,194	1,915,118
Harrison	209,280	9,889	5	1,656	16,380
Hart	289,280	117,226	41	1,188	139,236
Henderson	264,960	36,834	14	1,511	55,639
Henry	193,920	4,047	2	375	1,518
Hickman	143,360	35,667	25	1,770	63,122
Hopkins	355,200	147,093	41	1,263	185,750
Jackson	224,640	155,347	69	4,567	709,485
Jefferson	237,440	9,700	4	402	3,905
Jessamine	102,400	5,888	5	754	4,902
Johnson	167,424	67,706	40	2,040	138,205
Kenton	113,280	2,052	2	1,781	3,655
Knott	223,116	186,659	84	4,860	907,670
Knox	225,280	133,413	29	2,779	370,700
Larue	191,360	44,954	23	2,057	92,491
Laurel	286,720	159,478	56	2,113	337,011
Lawrence	273,447	98,601	36	1,880	186,067
Lee	128,000	91,287	71	1,925	175,765
Leslie	254,080	218,092	86	5,153	1,123,919
Letcher	226,680	177,511	78	8,120	1,441,712
Lewis	304,640	180,856	59	1,138	205,842
Lincoln	208,640	45,226	22	786	35,561
Livingston	244,480	93,895	38	1,419	133,274
Logan	373,120	140,427	38	1,094	153,617
Lyon	144,640	88,431	61	1,838	162,579
Madison	279,040	27,958	10	558	15,716
Magoffin	192,000	93,091	48	3,823	355,887
Marion	249,600	82,474	33	760	62,707
Marshall	212,480	83,302	39	1,302	108,454
Martin	146,777	97,861	67	3,740	365,987
Mason	130,560	1,991	2	2,247	4,473
McCracken	154,240	15,503	10	648	10,065

Name of County	Total Area in Acres.	Area Forested Acres	Per Cent. of Forest.	Average Stand Per Acre Bd. Ft.	Total M. Ft. Bd. M.
McLean	161,920	74,054	46	2,659	222,894
Meade	194,560	57,034	29	949	54,151
Menifee	127,360	84,884	67	2,656	225,498
Mercer	162,560	7,809	5	327	2,550
Metcalfe	184,320	82,647	45	1,658	137,053
Monroe	211,840	109,259	52	2,661	290,763
Montgomery	128,640	36,315	28	1,074	38,987
Morgan	240,000	115,588	48	2,679	309,695
Muhlenberg	280,320	62,406	39	1,849	204,460
Nelson	277,760	60,616	22	1,500	90,924
Nicholas	143,360	3,279	2	2,483	8,141
Ohio	366,080	88,143	24	1,151	101,150
Oldham	115,840	8,727	8	500	4,364
Owen	256,000	16,862	7	704	11,871
Owsley	131,840	78,915	60	4,024	316,863
Pendleton	163,200	3,208	2	2,004	6,430
Perry	214,400	171,484	80	5,009	858,916
Pike	527,787	437,880	83	4,570	2,004,601
Powell	113,280	64,031	57	1,672	107,077
Pulaski	482,560	285,062	59	956	272,574
Robertson	61,440	2,180	4	2,365	5,156
Rockcastle	197,120	130,371	66	1,890	246,425
Rowan	172,800	112,406	65	1,777	199,771
Russell	224,640	144,090	64	1,825	262,899
Scott	145,920	7,071	5	773	5,185
Shelby	252,800	3,515	2	663	2,331
Simpson	121,600	22,853	19	961	21,973
Spencer	130,560	3,917	3	400	1,567
Taylor	140,160	31,494	22	1,929	60,762
Todd	238,720	62,406	26	1,591	99,293
Trigg	307,840	191,600	62	2,556	489,766
Trimble	84,480	9,777	12	1,420	13,883
Union	247,680	12,454	5	1,196	14,889
Warren	337,920	76,575	23	1,095	83,861
Washington	204,160	4,147	2	1,000	4,147
Wayne	394,880	281,883	71	2,968	836,691
Webster	227,200	35,269	15	1,071	37,782
Whitley	318,220	215,822	68	2,255	486,703
Wolfe	152,960	88,794	58	2,577	230,843
Woodford	216,320	15,000	7	1,142	16,655

Grand total 24,156,554 M. Ft. B. M.

STAND OF TIMBER BY COUNTIES

The stand of timber in each county is given in thousand feet board measure. (M. Ft. B. M.)

ADAIR

Species	M. Ft. B. M.
White Oak	31,371
Black Oak	39,423
Beech	19,162
Poplar	6,929
Chestnut	17,160
Hickory	22,104
Maple	5,872
Gum	2,822
Basswood	1,936
Yellow Pine	
Walnut	484
Sycamore	5,246
Elm	1,146
Post Oak	1,043
Scattered	5,445
	160,143

ALLEN

Species	M. Ft. B. M.
White Oak	12,213
Black Oak	38,881
Beech	14,702
Poplar	8,162
Chestnut	948
Hickory	3,959
Maple	8,151
Gum	926
Ash	101
Walnut	109
Sycamore	2,761
Elm	1,025
Post Oak	201
Scattered	3,523
	95,662

ANDERSON

Species	M. Ft. B. M.
White Oak	4,078
Black Oak	3,162
Beech	2,972
Poplar	243
Hickory	3,145
Maple	905
Gum	7
Ash	528
Basswood	6
Walnut	724
Sycamore	97
Elm	59
Cedar	8
Scattered	994
	16,928

BALLARD

Species	M. Ft. B. M.
White Oak	696
Black Oak	10,788
Poplar	360
Hickory	2,470
Maple	3,908
Gum	10,985
Ash	217
Sycamore	2,053
Cypress	9,591
Elm	6,043
Cottonwood	144
Post Oak	1,033
Scattered	1,129
	49,417

BARREN

Species	M. Ft. B. M.
White Oak	20,800
Black Oak	74,790
Beech	34,130
Poplar	12,162
Chestnut	16,074
Hickory	7,690
Maple	3,555
Gum	127
Walnut	2,216
Sycamore	5,368
Post Oak	451
Cedar	191
Scattered	196
	177,750

BELL

Species	M. Ft. B. M.
White Oak	180,177
Black Oak	83,832
Beech	81,068
Poplar	66,620
Chestnut	227,901
Hickory	29,407
Maple	66,610
Gum	20,753
Ash	9,595
Basswood	17,776
Yellow Pine	4,766
Chestnut Oak	211,680
Walnut	2,157
Hemlock	17,216
Buckeye	9,233
Birch	3,118
Cucumber	4,725
Cherry	286
Scattered	904
	1,037,824

BATH

Species	M. Ft. B. M.
White Oak	12,838
Black Oak	13,149
Beech	4,270
Poplar	4,480
Chestnut	2,471
Hickory	5,510
Maple	4,685
Gum	8,047
Ash	1,850
Basswood	1,413
Yellow Pine	6,160
Chestnut Oak	5,014
Walnut	622
Locust	1,539
Buckeye	146
Cucumber	146
Elm	780
Sycamore	3,779
	76,899

BOONE

Species	M. Ft. B. M.
White Oak	409
Black Oak	381
Beech	369
Poplar	8
Hickory	114
Maple	234
Ash	16
Basswood	27
Walnut	25
Locust	73
Elm	41
Scattered	108
	1,796

BOURBON

Species	M. Ft. B. M.
White Oak	2,050
Black Oak	575
Beech	247
Hickory	822
Maple	818
Ash	1,230
Walnut	1,640
Sycamore	165
Elm	164
Hackberry	163
Scattered	328
	8,202

BOYD

Species	M. Ft. B. M.
White Oak	14,934
Black Oak	26,134
Beech	11,167
Poplar	525
Chestnut	2,499
Hickory	1,915
Maple	3,254
Yellow Pine	1,400
Chestnut Oak	7,958
Scattered	1,978
	70,864

BOYLE

Species	M. Ft. B. M.
White Oak	811
Black Oak	1,484
Beech	1,247
Poplar	239
Chestnut	1,512
Hickory	774
Maple	512
Gum	4
Ash	242
Yellow Pine	59
Chestnut	353
Walnut	291
Sycamore	15
Scattered	290
	7,833

BRACKEN

Species	M. Ft. B. M.
White Oak	2,560
Black Oak	1,387
Beech	223
Hickory	751
Maple	634
Ash	333
Walnut	123
Sycamore	15
Elm	194
Locust	173
Scattered	115
	6,508

BREATHITT

Species	M. Ft. B. M.
White Oak	279,390
Black Oak	21,482
Beech	122,822
Poplar	68,501
Chestnut	83,825
Hickory	56,316
Maple	18,159
Gum	12,716
Ash	1,767
Basswood	14,162
Yellow Pine	12,720
Chestnut Oak	166,134
Walnut	283
Hemlock	11,073
Buckeye	6,279
Scattered	669
	876,298

BRECKINRIDGE

Species	M. Ft. B. M.
White Oak	13,231
Black Oak	13,235
Beech	6,617
Poplar	440
Chestnut	822
Hickory	2,205
Maple	884
Gum	880
Ash	439
Basswood	444
Sycamore	441
Elm	882
Post Oak	1,324
Scattered	2,205
	44,049

BULLITT

Species	M. Ft. B. M.
White Oak	3,449
Black Oak	26,012
Beech	20,352
Poplar	622
Chestnut	789
Hickory	791
Maple	1,413
Gum	957
Ash	394
Basswood	394
Yellow Pine	2,445
Sycamore	621
Elm	623
Post Oak	1,245
Cedar	787
Scattered	1,367
	62,261

BUTLER

Species	M. Ft. B. M.
White Oak	8,053
Black Oak	21,588
Beech	40,248
Poplar	3,186
Chestnut	3,186
Hickory	3,078
Maple	2,015
Gum	4,819
Ash	531
Sycamore	2,272
Elm	1,155
Post Oak	2,165
Scattered	4,087
	96,383

CALDWELL

Species	M. Ft. B. M.
White Oak	42,053
Black Oak	45,749
Beech	3,286
Poplar	7,140
Hickory	9,687
Maple	2,012
Gum	9,462
Ash	296
Sycamore	1,757
Elm	985
Post Oak	6,732
	137,259

CALLOWAY

Species	M. Ft. B. M.
White Oak	5,843
Black Oak	65,938
Beech	6,061
Poplar	3,157
Chestnut	752
Hickory	6,095
Gum	21,367
Ash	970
Sycamore	968
Birch	966
Elm	2,906
Post Oak	6,089
Scattered	750
	121,862

CAMPBELL

Species	M. Ft. B. M.
White Oak	1,889
Black Oak	960
Beech	165
Poplar	31
Hickory	337
Maple	266
Ash	131
Walnut	121
Locust	107
Sycamore	72
Elm	115
Scattered	47
	4,241

CARLISLE

Species	M. Ft. B. M.
White Oak	5,293
Black Oak	19,746
Beech	685
Poplar	2,205
Chestnut	75
Hickory	11,026
Maple	3,429
Gum	14,827
Ash	688
Sycamore	3,425
Birch	1,371
Cypress	682
Elm	6,854
Post Oak	373
Cottonwood	2,056
Scattered	3,264
	75,999

CARROLL

Species	M. Ft. B. M.
White Oak	961
Black Oak	639
Beech	1,779
Poplar	282
Chestnut	
Hickory	179
Maple	773
Ash	56
Basswood	52
Walnut	58
Sycamore	239
Elm	132
Scattered	202
	5,352

CARTER

Species	M. Ft. B. M.
White Oak	35,056
Black Oak	74,962
Beech	17,978
Poplar	700
Chestnut	8,389
Hickory	8,364
Maple	7,464
Ash	20
Basswood	50
Yellow Pine	1,200
Chestnut Oak	10,214
Hemlock	100
Scattered	1,225
	165,722

CASEY

Species	M. Ft. B. M.
White Oak	4,335
Black Oak	2,146
Beech	1,075
Poplar	1,112
Chestnut	1,230
Hickory	15
Maple	506
Gum	1,460
Chestnut Oak	467
Sycamore	253
Post Oak	30
Scattered	874
	221,842

CHRISTIAN

Species	M. Ft. B. M.
White Oak	29,551
Black Oak	72,698
Beech	13,186
Poplar	11,356
Hickory	18,167
Maple	2,754
Gum	10,293
Ash	508
Basswood	353
Walnut	1,744
Sycamore	1,983
Elm	1,436
Post Oak	12,353
Scattered	2,138
	178,520

CLARK

Species	M. Ft. B. M.
White Oak	4,335
Black Oak	2,146
Hickory	1,075
Maple	1,112
Ash	1,230
Basswood	15
Chestnut Oak	506
Walnut	1,460
Sycamore	467
Elm	253
Cedar	30
Scattered	874
	13,503

CLAY

Species	M. Ft. B. M.
White Oak	250,773
Black Oak	45,223
Beech	50,108
Poplar	7,975
Chestnut	63,295
Hickory	41,420
Maple	9,337
Gum	3,078
Ash	1,188
Basswood	6,246
Yellow Pine	11,156
Chestnut Oak	179,211
Walnut	382
Hemlock	530
Buckeye	4,228
Scattered	1,765
	675,915

CLINTON

Species	M. Ft. B. M.
White Oak	9,827
Black Oak	15,354
Beech	7,984
Poplar	4,913
Chestnut	6,141
Hickory	4,913
Maple	617
Gum	3,068
Ash	616
Sycamore	615
Elm	1,229
Post Oak	3,071
Cedar	1,229
Scattered	1,843
	61,420

CRITTENDEN

Species	M. Ft. B. M.
White Oak	11,467
Black Oak	19,988
Beech	286
Poplar	843
Hickory	2,693
Maple	787
Gum	6,666
Ash	665
Sycamore	908
Cypress	65
Elm	919
Cottonwood	59
Post Oak	4,559
Scattered	247
	50,152

CUMBERLAND

Species	M. Ft. B. M.
White Oak	13,146
Black Oak	22,555
Beech	36,456
Poplar	5,470
Chestnut	8,614
Hickory	19,678
Maple	3,602
Gum	2,816
Ash	4,225
Sycamore	1,245
Elm	1,571
Post Oak	16,146
Cedar	1,409
Scattered	3,909
	140,842

DAVIESS

Species	M. Ft. B. M.
White Oak	19,477
Black Oak	41,183
Beech	8,387
Poplar	15,657
Chestnut	2,784
Hickory	21,009
Maple	17,173
Gum	30,875
Ash	8,653
Basswood	3,090
Walnut	613
Sycamore	25,177
Cypress	4,031
Elm	18,785
Cottonwood	3,699
	220,593

EDMONSON

Species	M. Ft. B. M.
White Oak	8,295
Black Oak	24,884
Beech	4,808
Poplar	1,665
Chestnut	2,382
Hickory	2,767
Maple	1,104
Gum	1,106
Ash	552
Walnut	553
Sycamore	1,655
Elm	1,299
Post Oak	1,108
Cedar	361
Scattered	2,863
	55,302

ELLIOTT

Species	M. Ft. B. M.
White Oak	27,500
Black Oak	14,300
Beech	11,000
Chestnut	7,700
Hickory	5,500
Yellow Pine	7,700
Chestnut Oak	29,700
Hemlock	3,300
Scattered	3,300
	110,000

ESTILL

Species	M. Ft. B. M.
White Oak	7,067
Beech	28,496
Black Oak	22,563
Poplar	4,161
Chestnut	8,899
Hickory	19,419
Maple	27,095
Gum	1,927
Sycamore	34
Basswood	3,679
Yellow Pine	1,004
Chestnut Oak	3,199
Buckeye	1,985
	129,528

FAYETTE

Species	M. Ft. B. M.
White Oak	707
Black Oak	402
Beech	22
Chestnut	4
Hickory	536
Maple	500
Ash	1,503
Walnut	2,055
Sycamore	76
Elm	59
Hackberry	306
Scattered	135
	6,305

FLEMING

Species	M. Ft. B. M.
White Oak	8,133
Black Oak	9,305
Beech	1,901
Poplar	1,399
Chestnut	2,321
Hickory	3,117
Maple	1,944
Gum	1,326
Ash	1,095
Yellow Pine	1,990
Chestnut Oak	3,316
Locust	49
Walnut	76
Sycamore	351
Elm	30
Scattered	714
	37,067

FLOYD

Species	M. Ft. B. M.
White Oak	115,319
Black Oak	31,622
Beech	142,242
Poplar	10,559
Chestnut	25,058
Hickory	18,450
Maple	137,770
Gum	1,884
Ash	1,699
Basswood	6,319
Yellow Pine	2,616
Chestnut Oak	114,331
Locust	141
Cucumber	2,870
	610,880

FRANKLIN

Species	M. Ft. B. M.
White Oak	879
Black Oak	541
Beech	197
Poplar	2
Chestnut	
Hickory	412
Maple	246
Ash	643
Walnut	804
Sycamore	51
Elm	46
Cedar	48
Scattered	191
Basswood	16
	4,076

FULTON

Species	M. Ft. B. M.
White Oak	1,094
Black Oak	5,958
Beech	56
Poplar	820
Hickory	3,687
Maple	740
Gum	17,908
Ash	3,693
Walnut	54
Sycamore	10,525
Cypress	10,252
Elm	11,620
Cottonwood	6,836
Scattered	1,477
	73,820

GALLATIN

Species	M. Ft. B. M.
White Oak	142
Black Oak	158
Beech	145
Poplar	4
Hickory	48
Maple	101
Basswood	13
Ash	8
Walnut	11
Sycamore	36
Elm	20
Cedar	
Scattered	43
	729

GARRARD

Species	M. Ft. B. M.
White Oak	1,552
Black Oak	1,234
Beech	72
Poplar	5
Hickory	496
Maple	796
Gum	24
Ash	1,077
Basswood	111
Walnut	895
Sycamore	428
Elm	166
Cedar	226
Hackberry	36
Scattered	719
	7,837

GRANT

Species	M. Ft. B. M.
White Oak	1,834
Black Oak	2,201
Beech	1,467
Poplar	45
Hickory	588
Maple	395
Basswood	71
Walnut	28
Sycamore	220
Elm	75
Scattered	415
	7,339

GRAVES

Species	M. Ft. B. M.
White Oak	9,980
Black Oak	17,048
Beech	171
Poplar	3,576
Chestnut	514
Hickory	2,260
Maple	453
Gum	10,917
Ash	386
Sycamore	729
Cypress	468
Elm	2,414
Post Oak	630
Scattered	1,685
	51,231

GRAYSON

Species	M. Ft. B. M.
White Oak	6,987
Black Oak	37,164
Beech	7,090
Poplar	1,645
Chestnut	3,103
Hickory	6,810
Maple	2,397
Gum	2,345
Ash	752
Walnut	229
Sycamore	231
Elm	1,504
Post Oak	3,334
Cedar	233
Scattered	1,362
	75,186

GREEN

Species	M. Ft. B. M.
White Oak	2,804
Black Oak	33,727
Beech	10,511
Poplar	3,049
Chestnut	2,804
Hickory	5,690
Maple	530
Gum	1,138
Walnut	526
Sycamore	231
Scattered	206
	61,216

GREENUP

Species	M. Ft. B. M.
White Oak	27,200
Black Oak	75,430
Beech	12,402
Poplar	3,090
Chestnut	10,065
Hickory	2,885
Maple	1,000
Yellow Pine	6,427
Chestnut Oak	5,760
Scattered	5,715
	149,794

HANCOCK

Species	M. Ft. B. M.
White Oak	1,537
Black Oak	2,656
Beech	699
Poplar	72
Chestnut	34
Hickory	348
Maple	139
Gum	1,048
Sycamore	68
Elm	36
Post Oak	352
	6,989

HARDIN

Species	M. Ft. B. M.
White Oak	1,279
Black Oak	18,731
Beech	2,053
Chestnut	927
Hickory	2,757
Maple	178
Gum	575
Ash	174
Sycamore	177
Elm	552
Post Oak	9,797
Cedar	175
Scattered	176
	37,551

HARLAN

Species	M. Ft. B. M.
White Oak	315,769
Black Oak	203,839
Beech	102,536
Poplar	88,854
Chestnut	406,820
Hickory	43,250
Maple	172,453
Gum	17,361
Ash	3,541
Basswood	61,622
Yellow Pine	6,180
Chestnut Oak	385,423
Walnut	2,687
Hemlock	33,724
Birch	30,820
Buckeye	25,749
Cucumber	12,880
Cherry	1,610
	1,915,118

HARRISON

Species	M. Ft. B. M.
White Oak	6,141
Black Oak	3,345
Beech	149
Hickory	1,316
Maple	1,394
Ash	2,450
Walnut	231
Locust	516
Sycamore	258
Elm	283
Scattered	297
	16,380

HART

Species	M. Ft. B. M.
White Oak	12,924
Black Oak	65,012
Poplar	5,287
Chestnut	8,667
Hickory	11,864
Gum	440
Locust	438
Post Oak	29,422
Scattered	5,182
	139,236

HENDERSON

Species	M. Ft. B. M.
White Oak	8,254
Black Oak	17,388
Poplar	865
Hickory	2,693
Maple	786
Gum	18,097
Ash	1,037
Sycamore	1,491
Cypress	1,114
Elm	3,313
Cottonwood	212
Scattered	389
	55,639

HENRY

Species	M. Ft. B. M.
White Oak	228
Black Oak	303
Beech	333
Poplar	32
Hickory	78
Maple	379
Ash	74
Walnut	14
Sycamore	30
Elm	16
Scattered	31
	1,518

HICKMAN

Species	M. Ft. B. M.
White Oak	6,644
Black Oak	36,712
Poplar	332
Hickory	3,090
Maple	64
Gum	7,142
Sycamore	34
Birch	32
Cypress	399
Elm	1,994
Cottonwood	35
Post Oak	2,990
Scattered	3,654
	63,122

HOPKINS

Species	M. Ft. B. M.
White Oak	23,687
Black Oak	54,803
Beech	17,073
Poplar	5,574
Hickory	19,486
Maple	10,408
Gum	38,006
Ash	2,435
Sycamore	2,267
Elm	6,491
Cottonwood	1,327
Post Oak	3,425
Scattered	768
	185,750

JACKSON

Species	M. Ft. B. M.
White Oak	180,386
Black Oak	126,387
Beech	12,695
Poplar	25,964
Chestnut	103,878
Hickory	47,598
Maple	5,097
Gum	8,566
Ash	1,031
Basswood	3,692
Yellow Pine	68,997
Chestnut Oak	117,508
Walnut	2,226
Hemlock	605
Buckeye	2,690
Scattered	2,165
	709,485

JEFFERSON

Species	M. Ft. B. M.
White Oak	233
Black Oak	1,753
Beech	1,170
Poplar	39
Chestnut	38
Hickory	78
Maple	117
Gum	155
Ash	19
Basswood	19
Yellow Pine	37
Sycamore	40
Elm	41
Post Oak	78
Scattered	78
	3,905

JESSAMINE

Species	M. Ft. B. M.
White Oak	828
Black Oak	570
Beech	283
Poplar	18
Hickory	340
Maple	488
Gum	94
Ash	700
Basswood	38
Walnut	499
Locust	93
Elm	56
Cedar	95
Hackberry	500
Scattered	300
	4,902

JOHNSON

Species	M. Ft. B. M.
White Oak	40,507
Black Oak	35,724
Beech	11,152
Poplar	5,115
Chestnut	5,280
Hickory	8,883
Maple	2,139
Chestnut Oak	21,944
Hemlock	150
Scattered	7,311
	138,205

KENTON

Species	M. Ft. B. M.
White Oak	1,440
Black Oak	912
Beech	80
Poplar	7
Hickory	367
Maple	320
Ash	173
Walnut	95
Locust	94
Sycamore	58
Elm	66
Scattered	43
	3,655

KNOTT

Species	M. Ft. B. M.
White Oak	186,788
Black Oak	35,956
Beech	177,702
Poplar	29,836
Chestnut	48,057
Hickory	29,938
Maple	173,945
Ash	5,542
Basswood	23,024
Yellow Pine	111
Chestnut Oak	186,788
Walnut	89
Locust	3,362
Hemlock	521
Cucumber	6,011
	907,670

KNOX

Species	M. Ft. B. M.
White Oak	96,355
Black Oak	84,745
Beech	21,936
Poplar	15,818
Chestnut	51,239
Hickory	16,028
Maple	10,011
Gum	5,056
Ash	1,971
Basswood	7,252
Yellow Pine	599
Chestnut Oak	53,938
Buckeye	1,695
Scattered	4,057
	370,700

LARUE

Species	M. Ft. B. M.
White Oak	14,496
Black Oak	21,778
Beech	13
Poplar	15
Chestnut	22,499
Hickory	12,674
Maple	55
Chestnut Oak	12,074
Sycamore	36
Post Oak	5,757
Scattered	3,094
	92,491

LAUREL

Species	M. Ft. B. M.
White Oak	52,931
Black Oak	96,890
Beech	5,315
Poplar	9,961
Chestnut	17,870
Hickory	31,227
Maple	20,629
Gum	15,975
Ash	117
Basswood	3,585
Yellow Pine	38,345
Chestnut Oak	29,423
Walnut	117
Hemlock	10,767
Buckeye	852
Scattered	3,007
	337,011

LAWRENCE

Species	M. Ft. B. M.
White Oak	33,321
Black Oak	67,612
Beech	31,122
Poplar	600
Chestnut	7,607
Hickory	7,992
Maple	1,112
Yellow Pine	4,908
Chestnut Oak	20,489
Hemlock	70
Scattered	11,234
	186,067

LEE

Species	M. Ft. B. M.
White Oak	19,788
Black Oak	53,417
Beech	11,064
Poplar	11,761
Chestnut	15,064
Hickory	10,170
Maple	3,137
Gum	5,510
Basswood	4,102
Yellow Pine	19,649
Chestnut Oak	14,886
Hemlock	5,686
Buckeye	841
Scattered	690
	175,765

LESLIE

Species	M. Ft. B. M.
White Oak	320,125
Black Oak	61,173
Poplar	84,694
Chestnut	87,007
Hickory	38,351
Beech	112,497
Maple	61,933
Gum	27,942
Ash	4,738
Basswood	54,961
Yellow Pine	9,852
Chestnut Oak	170,242
Walnut	874
Sycamore	11,190
Hemlock	44,501
Buckeye	11,002
Birch	6,735
Cucumber	12,392
Scattered	3,710
	1,123,919

LETCHER

Species	M. Ft. B. M.
White Oak	278,195
Black Oak	41,811
Beech	165,452
Poplar	170,119
Chestnut	112,980
Hickory	62,110
Maple	171,331
Ash	32,861
Basswood	58,746
Chestnut Oak	278,195
Walnut	6,947
Locust	19,591
Hemlock	3,700
Cucumber	35,599
Cherry	4,075
	1,441,712

LEWIS

Species	M. Ft. B. M.
White Oak	28,625
Black Oak	72,008
Beech	16,642
Poplar	9,463
Chestnut	27,074
Hickory	16,031
Maple	6,045
Gum	1,621
Ash	1,749
Basswood	5,246
Yellow Pine	4,731
Chestnut Oak	13,235
Locust	437
Sycamore	437
Scattered	2,498
	205,842

LINCOLN

Species	M. Ft. B. M.
White Oak	2,871
Black Oak	12,024
Beech	3,344
Poplar	1,006
Chestnut	6,689
Hickory	2,675
Maple	1,000
Gum	1,338
Ash	532
Walnut	526
Sycamore	1,672
Scattered	1,884
	35,561

LIVINGSTON

Species	M. Ft. B. M.
White Oak	21,221
Black Oak	54,229
Beech	5,999
Poplar	4,353
Hickory	10,833
Maple	1,677
Gum	19,270
Ash	2,489
Basswood	155
Walnut	438
Sycamore	6,164
Cypress	286
Elm	3,675
Post Oak	1,126
Scattered	1,359
	133,274

LOGAN

Species	M. Ft. B. M.
White Oak	19,140
Black Oak	64,180
Beech	29,097
Poplar	1,913
Hickory	3,409
Maple	1,917
Gum	7,224
Ash	852
Basswood	766
Chestnut Oak	3,629
Walnut	383
Sycamore	7,226
Cedar	4,746
Scattered	9,135
	153,617

LYON

Species	M. Ft. B. M.
White Oak	54,924
Black Oak	50,320
Beech	2,913
Poplar	4,236
Hickory	13,110
Maple	2,249
Gum	13,737
Sycamore	1,189
Elm	1,364
Post Oak	18,537
	162,579

MADISON

Species	M. Ft. B. M.
White Oak	5,047
Black Oak	2,778
Beech	544
Chestnut	1,599
Hickory	1,587
Maple	1,687
Ash	473
Basswood	518
Walnut	106
Sycamore	187
Cedar	140
Hackberry	108
Scattered	942
	15,716

MAGOFFIN

Species	M. Ft. B. M.
White Oak	163,832
Black Oak	37,964
Beech	18,980
Poplar	24,750
Chestnut	16,282
Hickory	15,734
Maple	7,785
Gum	4,344
Basswood	8,556
Yellow Pine	3,746
Chestnut Oak	52,282
Sycamore	1,632
	355,887

MARION

Species	M. Ft. B. M.
White Oak	12,315
Black Oak	22,919
Beech	981
Poplar	156
Chestnut	5,996
Hickory	8,580
Maple	899
Ash	46
Chestnut Oak	5,446
Walnut	25
Sycamore	430
Elm	92
Post Oak	2,314
Scattered	2,508
	62,707

MARSHALL

Species	M. Ft. B. M.
White Oak	10,191
Black Oak	47,305
Beech	956
Poplar	4,769
Hickory	1,962
Maple	1,962
Gum	23,843
Ash	954
Sycamore	2,861
Birch	2,861
Cypress	1,908
Elm	5,031
Post Oak	654
Scattered	3,253
	108,454

MARTIN

Species	M. Ft. B. M.
White Oak	151,521
Black Oak	79,560
Beech	14,383
Poplar	31,005
Chestnut	11,310
Hickory	29,591
Chestnut Oak	27,914
Scattered	20,703
	365,987

MASON

Species	M. Ft. B. M.
White Oak	1,918
Black Oak	876
Beech	219
Poplar	91
Hickory	358
Maple	371
Ash	255
Walnut	77
Locust	148
Sycamore	24
Elm	68
Scattered	68
	4,473

McCRACKEN

Species	M. Ft. B. M.
White Oak	1,006
Black Oak	4,213
Poplar	396
Hickory	1,113
Maple	177
Gum	1,827
Ash	222
Sycamore	74
Cypress	148
Elm	449
Post Oak	267
Scattered	173
	10,065

McLEAN

Species	M. Ft. B. M.
White Oak	26,939
Black Oak	32,900
Beech	15,647
Poplar	6,901
Chestnut	315
Hickory	15,498
Maple	14,179
Gum	43,811
Ash	7,540
Basswood	1,348
Sycamore	9,808
Cypress	3,819
Elm	10,943
Cottonwood	4,701
Scattered	2,545
	222,894

MEADE

Species	M. Ft. B. M.
White Oak	4,104
Black Oak	26,643
Beech	8,792
Poplar	173
Chestnut	87
Hickory	4,488
Maple	2,198
Gum	2,707
Ash	455
Locust	
Sycamore	133
Hemlock	
Elm	542
Post Oak	1,475
Cedar	643
Scattered	1,711
	54,151

MENIFEE

Species	M. Ft. B. M.
White Oak	46,927
Black Oak	23,243
Beech	13,693
Poplar	24,353
Chestnut	16,267
Hickory	9,028
Maple	6,884
Gum	6,370
Ash	301
Basswood	3,568
Yellow Pine	11,292
Chestnut Oak	33,070
Locust	1,934
Sycamore	5,446
Hemlock	17,013
White Pine	6,109
	225,498

MERCER

Species	M. Ft. B. M.
White Oak	497
Black Oak	269
Beech	82
Poplar	3
Hickory	158
Maple	283
Gum	6
Ash	544
Basswood	7
Walnut	440
Sycamore	17
Elm	12
Cedar	5
Scattered	227
	2,550

METCALFE

Species	M. Ft. B. M.
White Oak	23,503
Black Oak	48,924
Beech	27,125
Poplar	11,657
Chestnut	3,479
Hickory	11,521
Mapel	1,049
Gum	375
Ash	669
Walnut	1,457
Sycamore	963
Elm	321
Post Oak	936
Scattered	5,074
	137,053

MONROE

Species	M. Ft. B. M.
White Oak	58,154
Black Oak	101,380
Beech	36,258
Poplar	21,374
Chestnut	36,199
Hickory	25,996
Maple	1,537
Gum	1,543
Ash	1,540
Sycamore	3,081
Scattered	3,701
	290,763

MONTGOMERY

Species	M. Ft. B. M.
White Oak	7,511
Black Oak	6,715
Beech	1,716
Chestnut	745
Hickory	2,670
Poplar	2,647
Maple	3,521
Gum	3,631
Ash	2,224
Basswood	689
Yellow Pine	1,405
Chestnut Oak	780
Walnut	156
Locust	2,202
Sycamore	2,114
Buckeye	48
Elm	213
	38,987

MORGAN

Species	M. Ft. B. M.
White Oak	74,621
Black Oak	39,753
Beech	23,582
Poplar	20,689
Chestnut	23,163
Hickory	21,107
Maple	16,000
Gum	26,440
Ash	3,010
Basswood	5,456
Yelow Pine	4,273
Chestnut Oak	42,889
Locust	283
Sycamore	2,111
Hemlock	4,075
Buckeye	889
Cucumber	1,350
	309,695

MUHLENBERG

Species	M. Ft. B. M.
White Oak	23,774
Black Oak	70,843
Beech	29,505
Poplar	2,645
Hickory	9,488
Maple	5,342
Gum	40,125
Ash	1,091
Sycamore	4,272
Cypress	196
Elm	3,135
Cottonwood	999
Post Oak	35
Scattered	13,016
	204,460

NELSON

Species	M. Ft. B. M.
White Oak	9,093
Black Oak	22,737
Beech	22,725
Poplar	1,818
Chestnut	2,728
Hickory	2,725
Maple	2,731
Gum	1,814
Ash	4,548
Yellow Pine	1,820
Sycamore	13,639
Post Oak	4,546
Scattered	
	90,924

NICHOLAS

Species	M. Ft. B. M.
White Oak	3,423
Black Oak	1,646
Beech	191
Poplar	50
Hickory	1,146
Maple	511
Ash	473
Basswood	24
Walnut	217
Locust	181
Sycamore	68
Elm	137
Scattered	74
	8,141

OHIO

Species	M. Ft. B. M.
White Oak	8,363
Black Oak	20,290
Beech	26,298
Poplar	1,014
Chestnut	1,263
Hickory	10,639
Maple	8,417
Gum	15,218
Ash	767
Sycamore	1,259
Elm	1,261
Post Oak	1,782
Scattered	4,579
	101,150

OLDHAM

Species	M. Ft. B. M.
White Oak	938
Black Oak	763
Beech	985
Poplar	238
Chestnut	12
Hickory	175
Maple	480
Ash	45
Gum	436
Basswood	10
Sycamore	109
Elm	22
Post Oak	41
Scattered	110
	4,364

OWEN

Species	M. Ft. B. M.
White Oak	3,100
Black Oak	2,935
Beech	1,992
Poplar	42
Hickory	1,240
Maple	725
Gum	44
Ash	128
Basswood	162
Walnut	43
Sycamore	431
Elm	230
Cedar	85
Scattered	704
	11,871

OWSLEY

Species	M. Ft. B. M.
White Oak	97,294
Black Oak	17,231
Beech	55,022
Poplar	20,523
Chestnut	18,092
Hickory	18,009
Maple	9,591
Gum	2,554
Ash	1,460
Basswood	4,792
Yellow Pine	5,321
Chestnut Oak	20,685
Hemlock	1,121
Buckeye	1,865
Scattered	3,303
	316,863

PENDLETON

Species	M. Ft. B. M.
White Oak	3,065
Black Oak	1,113
Beech	54
Hickory	641
Maple	699
Ash	346
Walnut	139
Locust	129
Elm	144
Scattered	100
	6,430

PERRY

Species	M. Ft. B. M.
White Oak	291,869
Black Oak	25,393
Beech	123,087
Poplar	49,806
Chestnut	103,807
Hickory	40,731
Maple	25,899
Gum	4,530
Ash	3,378
Basswood	24,603
Yellow Pine	13,789
Chestnut Oak	117,239
Walnut	2,288
Hemlock	8,189
Sycamore	2,774
Buckeye	20,726
Birch	808
	858,916

PIKE

Species	M. Ft. B. M.
White Oak	368,972
Black Oak	128,109
Beech	370,974
Poplar	92,166
Chestnut	132,888
Hickory	80,283
Maple	293,113
Gum	7,437
Ash	21,081
Basswood	57,117
Chestnut Oak	419,354
Walnut	4,671
Locust	6,419
Hemlock	7,122
Cucumber	12,532
Scattered	2,363
	2,004,601

POWELL

Species	M. Ft. B. M.
White Oak	18,520
Black Oak	19,111
Beech	11,673
Poplar	7,636
Hickory	6,333
Maple	4,156
Gum	2,352
Basswood	188
Ash	2,213
Yellow Pine	9,283
Chestnut Oak	10,308
Locust	1,339
Sycamore	1,608
Hemlock	4,749
Chestnut	7,608
	107,077

PULASKI

Species	M. Ft. B. M.
White Oak	39,423
Black Oak	67,532
Beech	13,806
Poplar	25,779
Chestnut	35,693
Hickory	12,325
Maple	3,677
Gum	4,979
Basswood	4,899
Yellow Pine	22,506
Chestnut Oak	13,580
Sycamore	2,686
Hemlock	18,965
Cedar	6,724
	272,574

ROBERTSON

Species	M. Ft. B. M.
White Oak	2,096
Black Oak	1,092
Beech	177
Poplar	85
Hickory	752
Maple	348
Basswood	6
Ash	208
Walnut	49
Locust	151
Sycamore	54
Elm	70
Scattered	68
	5,156

ROCKCASTLE

Species	M. Ft. B. M.
White Oak	31,750
Black Oak	39,317
Beech	7,152
Poplar	17,703
Chestnut	22,976
Hickory	23,853
Maple	8,828
Gum	24,207
Ash	3,905
Basswood	7,257
Yellow Pine	26,422
Chestnut Oak	15,751
Walnut	1,927
Locust	2,104
Sycamore	5,317
Buckeye	4,373
Cucumber	1,725
Cedar	1,858
	246,425

ROWAN

Species	M. Ft. B. M.
White Oak	43,421
Black Oak	58,216
Beech	9,902
Poplar	5,556
Chestnut	18,765
Hickory	15,367
Maple	4,426
Gum	1,379
Ash	689
Basswood	3,650
Yellow Pine	17,573
Chestnut Oak	16,143
Sycamore	1,989
Scattered	2,695
	199,771

RUSSELL

Species	M. Ft. B. M.
White Oak	31,536
Black Oak	120,775
Beech	21,798
Poplar	12,544
Chestnut	26,592
Hickory	25,880
Maple	1,745
Gum	1,463
Ash	1,749
Sycamore	882
Elm	2,629
Post Oak	11,179
Cedar	1,631
Scattered	2,496
	262,899

SCOTT

Species	M. Ft. B. M.
White Oak	1,285
Black Oak	930
Beech	235
Poplar	24
Hickory	566
Maple	414
Gum	23
Ash	499
Basswood	49
Sycamore	178
Walnut	730
Elm	45
Scattered	207
	5,185

SHELBY

Species	M. Ft. B. M.
White Oak	582
Black Oak	232
Beech	559
Poplar	24
Hickory	236
Maple	279
Ash	234
Walnut	48
Sycamore	46
Elm	22
Scattered	69
	2,331

SIMPSON

Species	M. Ft. B. M.
White Oak	432
Black Oak	12,158
Beech	423
Poplar	55
Chestnut	111
Hickory	1,831
Maple	897
Gum	564
Ash	275
Sycamore	330
Elm	440
Post Oak	3,295
Scattered	1,171
	21,973

SPENCER

Species	M. Ft. B. M.
White Oak	282
Black Oak	235
Beech	345
Poplar	15
Hickory	126
Maple	158
Ash	156
Walnut	16
Sycamore	125
Elm	78
Scattered	31
	1,567

TAYLOR

Species	M. Ft. B. M.
White Oak	7,630
Black Oak	23,027
Beech	2,130
Poplar	1,090
Chestnut	9,403
Hickory	5,679
Maple	1,888
Gum	1,024
Chestnut Oak	1,781
Sycamore	965
Elm	134
Post Oak	3,661
Scattered	2,350
	60,762

TODD

Species	M. Ft. B. M.
White Oak	23,695
Black Oak	37,994
Beech	4,485
Poplar	3,490
Chestnut	1,811
Hickory	10,546
Maple	2,301
Gum	3,691
Ash	353
Basswood	212
Yellow Pine	965
Walnut	116
Sycamore	1,737
Elm	209
Post Oak	6,698
Scattered	990
	99,293

TRIGG

Species	M. Ft. B. M.
White Oak	128,255
Black Oak	203,619
Beech	1,326
Poplar	21,772
Hickory	46,775
Maple	11,466
Gum	42,433
Sycamore	5,179
Elm	3,402
Post Oak	25,539
	489,766

TRIMBLE

Species	M. Ft. B. M.
White Oak	2,704
Black Oak	1,378
Beech	5,830
Poplar	1,081
Hickory	19
Maple	1,617
Ash	104
Basswood	62
Walnut	149
Sycamore	320
Elm	194
Cedar	1
Scattered	424
	13,883

UNION

Species	M. Ft. B. M.
White Oak	2,438
Black Oak	4,930
Poplar	324
Hickory	1,051
Maple	166
Gum	4,299
Ash	247
Sycamore	500
Cypress	134
Elm	313
Cottonwood	330
Scattered	157
	14,889

WARREN

Species	M. Ft. B. M.
White Oak	7,928
Black Oak	50,029
Beech	9,662
Poplar	3,906
Chestnut	896
Hickory	2,918
Maple	2,516
Gum	3,182
Ash	896
Sycamore	57
Elm	115
Post Oak	574
Cedar	172
Scattered	1,010
	83,861

WASHINGTON

Species	M. Ft. B. M.
White Oak	622
Black Oak	1,037
Beech	1,245
Poplar	41
Hickory	208
Maple	415
Ash	43
Walnut	39
Sycamore	124
Elm	83
Post Oak	124
Scattered	166
	4,147

WAYNE

Species	M. Ft. B. M.
White Oak	132,742
Black Oak	79,983
Beech	29,619
Poplar	74,044
Chestnut	80,933
Hickory	63,786
Maple	58,447
Gum	79,346
Ash	23,999
Basswood	28,015
Yellow Pine	21,818
Chestnut Oak	65,392
Walnut	5,658
Locust	4,987
Sycamore	28,613
Hemlock	11,209
Buckeye	15,456
Cucumber	19,074
Cedar	13,570
	836,691

WEBSTER

Species	M. Ft. B. M.
White Oak	5,504
Black Oak	14,704
Beech	1,274
Poplar	187
Hickory	3,968
Maple	926
Gum	9,507
Ash	240
Sycamore	211
Elm	440
Post Oak	701
Scattered	120
	37,782

WHITLEY

Species	M. Ft. B. M.
White Oak	114,744
Black Oak	129,095
Beech	24,333
Poplar	35,568
Chestnut	21,771
Hickory	15,506
Maple	17,889
Gum	7,388
Ash	4,269
Basswood	7,170
Yellow Pine	56,231
Chestnut Oak	20,984
Hemlock	25,224
Buckeye	3,643
Cucumber	2,580
Scattered	308
	486,703

WOLFE

Species	M. Ft. B. M.
White Oak	28,587
Black Oak	39,226
Beech	13,297
Poplar	13,591
Hickory	19,158
Maple	15,333
Gum	23,519
Ash	899
Basswood	4,308
Yellow Pine	10,448
Chestnut Oak	16,615
Sycamore	1,423
Hemlock	3,421
Buckeye	781
White Pine	9,488
Cucumber	1,452
Chestnut	29,297
	230,843

WOODFORD

Species	M. Ft. B. M.	Species	M. Ft. B. M.
White Oak	2,202	Basswood	46
Black Oak	1,323	Walnut	4,505
Beech	444	Sycamore	356
Poplar	22	Elm	264
Hickory	1,518	Cedar	44
Maple	1,985	Hackberry	20
Gum	45	Scattered	578
Ash	3,303		
			16,655

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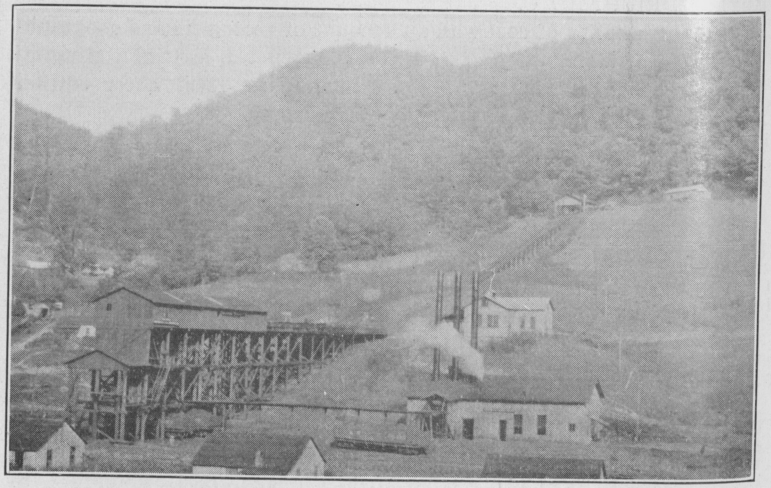
THE PRODUCTION OF COAL IN KENTUCKY.

By Willard R. Jillson

State Geologist of Kentucky.

INTRODUCTORY

The unparalleled expansion of the coal mining industry in Kentucky during the past decade has established figures of production which are little short of amazing. This is especially true of the Eastern Coal Field, which may be said to have received during the latter part of this decade, its principal development. The total production of coal in Kentucky for the year 1906 was 9,653,647 short tons. The total production of coal

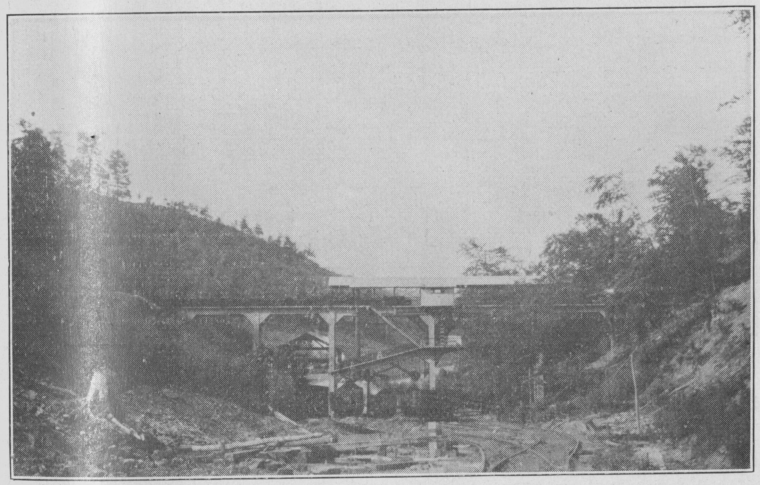


A UNIT COAL MINE ON BEAVER CREEK.

The view shows the main entry to the mine on the hillside, the tipple, power plant and office in the middle foreground, and a few of the miners' houses at the bottom of picture. Photo by W. R. Jillson. April, 1919.

in Kentucky for the year 1918 was 31,530,442 short tons, an annual growth of 1,824,000 shorts, or something over 200 per cent. Back of and responsible for the

tremendous increase in coal production in this state is a correspondingly widening interest and faith in the coal resources of Kentucky. The following figures of production have been compiled from all available sources, in-



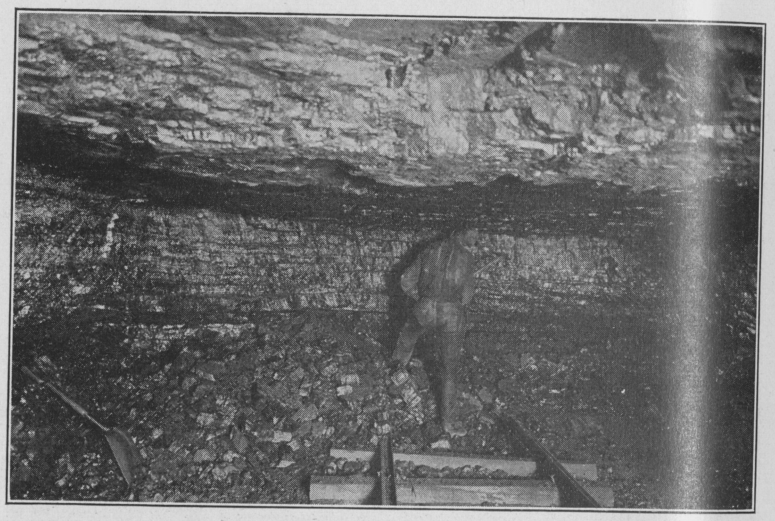
A DOUBLE TIPPLE.

At the head of small creeks and branches in Eastern Kentucky coal is most adantageously worked by use of a bridging tipple, as shown above. Photo by W. R. Jillson. April, 1918.

cluding the Mineral Resources of the United States Geological Survey, and the annual publications of the Kentucky State Department of Mines, to meet a growing demand for summary production data and allied information on this important mineral resource.

Statistics of Production

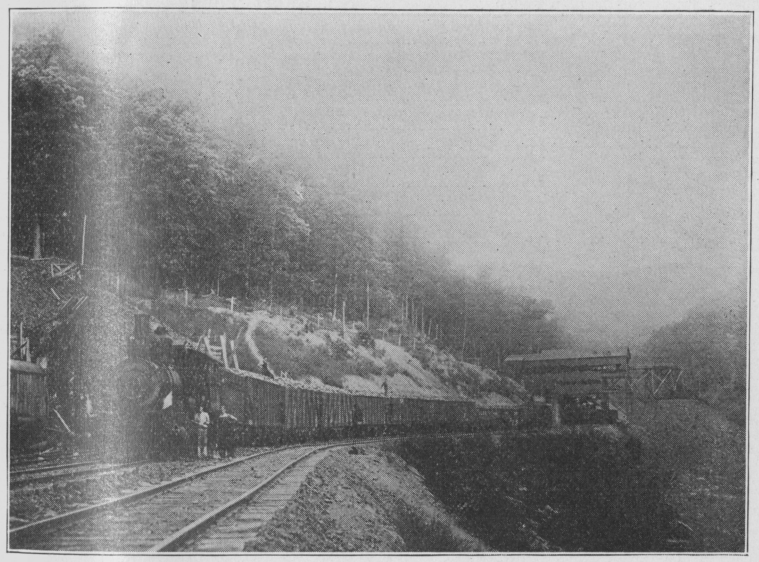
Although much coal was mined and sold in Kentucky in the early part of the nineteenth century, the most of it found domestic consumption within the state and the greater portion was used by the miners themselves, who were mostly farmers, for their own use. The first export of coal from Kentucky occurred in the year 1828 and with this year the beginning of the industry on a commercialized basis was established. Since 1828 the growth in the production of coal has been steady and



THE PLACE OF PERPETUAL NIGHT.

The head of a side entry in an Eastern Kentucky coal mine. The upper bench has been partly loaded.

consistent with the character and location of the principal coal fields. During the early part of the nineteenth century the principal coal areas in Kentucky could not be commercialized because of the lack of railroad or other transportation facilities. This retarded state of affairs would not allow the coal which could have been produced to compete with that of other more favorably located north, northeastern and northwestern fields in adjoining states. The era of enlargement and extension of the railroad system in Kentucky is directly reflected in the increased production of coal in this state, and one of the very best examples of the applicableness of this statement is the growth of the coal production in the Elkhorn and other headwater coal fields of the Southeastern District. The figures of coal production for 1828 to 1918, inclusive, have been compiled and are presented herewith. These statistics show that in eight years, from 1911 to 1918, there were produced in Kentucky 176,105,234 short tons of coal. From 1828 to 1910, inclusive, a total of eighty-two years, there was produced 157,971,800 short tons of coal. By subtraction then it is seen that the last



COAL ENROUTE TO THE CONSUMER.

The railroads play a very important part in the coal industry. The run of each mine must be moved each day to insure continued production. The above view was taken on the headwaters of Beaver Creek, Floyd County, Kentucky. Photo by W. R. Jillson. 1918.

eight years has produced an excess of 18,133,434 short tons of coal over the preceding eighty-two years. The figures of production are as follows:

PRODUCTION OF COAL IN KENTUCKY
1828 to 1917.

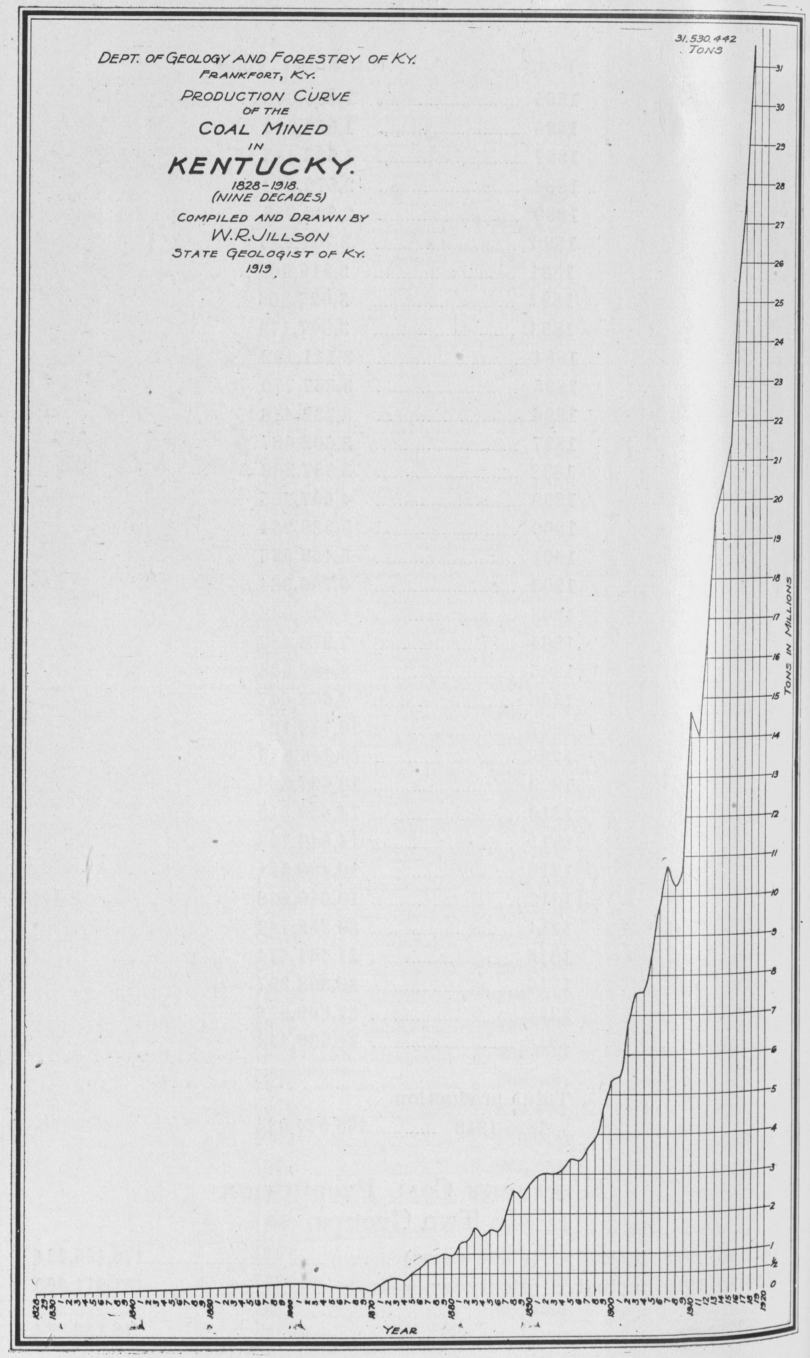
Year	No. Short Tons
1828	328
1829	2,000
1830	2,000
1831	2,100
1832	2,500
1833	2,750
1834	5,000
1835	6,000
1836	8,000
1837	10,000
1838	11,500
1839	16,000
1840	23,527

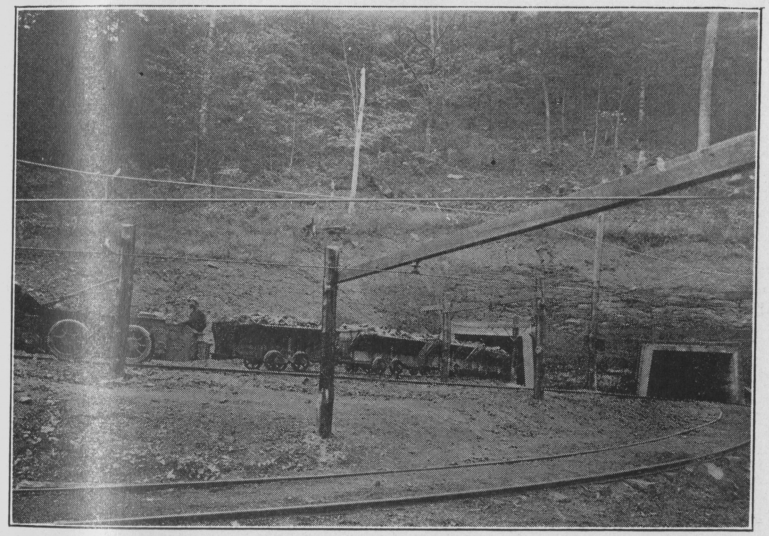
Year	No. Short Tons
1841	35,000
1842	50,000
1843	60,000
1844	75,000
1845	100,000
1846	115,000
1847	120,000
1848	125,000
1849	140,000
1850	150,000
1851	160,000
1852	175,000
1853	180,000
1854	190,000
1855	200,000
1856	215,000
1857	240,000
1858	250,000
1859	275,000
1860	285,760
1861	280,000
1862	275,000
1863	250,000
1864	250,000
1865	200,000
1866	180,000
1867	175,000
1868	160,000
1869	160,000
1870	150,582
1871	250,000
1872	380,800
1873	400,000
1874	360,000
1875	500,000
1876	650,000
1877	850,000
1878	900,000
1879	1,000,000
1880	946,288
1881	1,232,000
1882	1,300,000
1883	1,650,000
1884	1,550,000

Year	No. Short Tons
1885	1,600,000
1886	1,550,000
1887	1,933,185
1888	2,570,000
1889	2,399,755
1890	2,701,496
1891	2,916,069
1892	3,025,303
1893	3,007,179
1894	3,111,192
1895	3,357,770
1896	3,333,478
1897	3,602,097
1898	3,887,908
1899	4,607,255
1900	5,328,964
1901	5,469,986
1902	6,766,984
1903	7,538,032
1904	7,576,482
1905	8,432,523
1906	9,653,647
1907	10,753,124
1908	10,246,533
1909	10,697,384
1910	14,623,319
1911	14,049,703
1912	16,490,521
1913	19,616,600
1914	20,382,763
1915	21,361,674
1916	25,393,997
1917	27,809,976
1918	31,530,442
Total production 1829-1918	365,077,034

Kentucky Coal Production In Two Groups.

1911 to 1918, inclusive (eight years)	176,105,234
1828 to 1910, inclusive (eighty-two years)	157,971,800
Excess	18,133,434



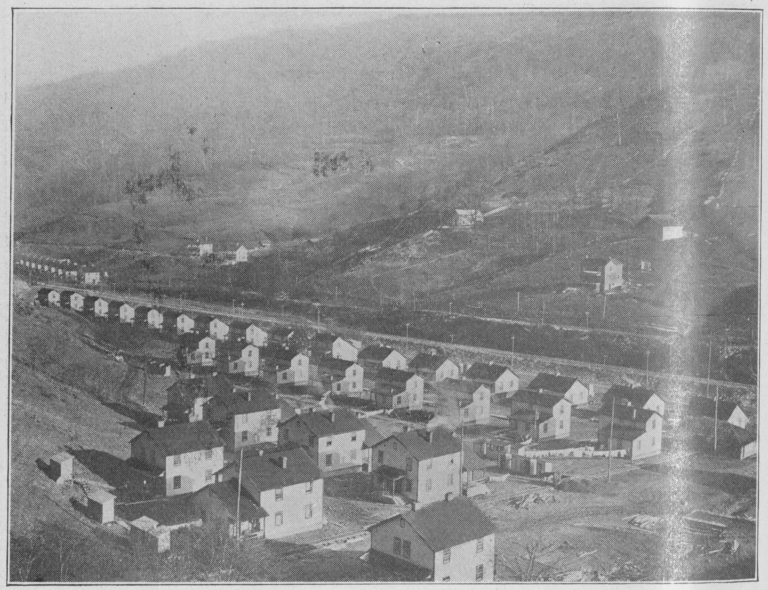


A DOUBLE ENTRY MINE.

The view is in Eastern Kentucky on the head of Left Beaver Creek, in Floyd County. A loaded train motor drawn is seen leaving the mine. Photo by W. R. Jillson. 1918.

Coal Production by Decades

The total coal production figures by decades during the past ninety years for this state are quite as interesting, if not more informative, than those of the separate years. The summary of production for the eight decades, from 1828 to 1907, inclusive, is 122,404,564 short tons. The summary of production for the ninth decade, from 1908 to 1917, inclusive, is 180,672,470 short tons, giving an increase in production in the ninth decade over that of the total production for the preceding eight decades of 58,267,906 short tons. Coal production figures by decades are as follows:



AN EASTERN KENTUCKY COAL TOWN.

The view shows the miners' houses, only, the business section being located farther up the creek. Photo by W. R. Jillson. 1918.

1828 to 1837	40,678
1838 to 1847	606,027
1848 to 1857	1,775,000
1858 to 1867	2,420,760
1868 to 1877	3,861,382
1878 to 1887	13,661,473
1888 to 1897	30,024,339
1898 to 1907	70,014,905
Total eight decades	122,404,564
1908 to 1917 (ninth decade)	180,672,470
1828 to 1907 (eight decades)	122,404,564
Excess	58,267,906
Total production (1828-1917)	334,077,034

Coal Produced in Kentucky in 1915 and 1916.

1915

County	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Eastern District:									
Bell	2,210,498	47,769	48,564		2,306,831	$2,414,790	$1.05	3,551	209
Boyd	73,211	2,871	1,918		78,000	65,872	.84	164	191
Breathitt, Greenup, Knott, Lawrence and Lee	67,401	6,218	973		74,592	77,541	1.04	114	207
Carter	65,152	3,649	14,612		83,413	89,669	1.08	161	179
Floyd	510,059	26,164	8,851		545,074	566,174	1.04	711	178
Harlan	1,390,346	12,312	15,677	308,463	1,726,798	1,827,144	1.06	1,496	226
Jackson and Pulaski	1,837	3,581			5,418	6,895	1.27	17	147
Johnson	928,645	17,897	28,922		975,464	1,267,332	1.30	1,282	221
Knox	746,796	5,043	15,874		767,713	815,986	1.06	1,480	195
Laurel	84,302	55	779		85,136	84,896	.99	229	143
Letcher	2,204,129	12,234	12,971		2,229,334	2,656,628	1.19	2,159	226
McCreary	566,767	1,781	987		569,535	642,244	1.13	970	173
Morgan	51,410	5,762	1,643		58,815	128,450	2.18	202	254
Perry	532,998	2,261	12,703		547,962	615,690	1.12	724	242
Pike	2,648,211	37,043	50,913	94,072	2,830,239	2,689,825	.95	2,928	211
Whitley	776,450	7,684	21,312		805,446	1,068,984	1.33	1,782	162
	12,858,212	192,324	236,699	402,535	13,689,770	15,018,120	1.10	17,970	205
Western District:									
Christian and McLean	92,356	350	550		93,256	85,503	.92	184	176
Daviess	6,000	35,320	1,458		42,778	41,157	.96	67	232
Hancock	1,000	3,000			4,000	5,425	1.36	12	190
Henderson	103,787	52,896	10,021		166,704	184,834	1.11	261	195
Hopknis	2,129,808	49,568	97,197	55,570	2,332,143	1,843,827	.79	2,737	149
Muhlenberg	2,159,213	22,559	50,273		2,232,045	1,844,506	.83	3,451	143
Ohio	463,168	33,906	22,746		519,820	417,373	.80	1,108	111
Union	653,818	47,679	40,613		742,110	708,440	.95	756	213
Webster	1,354,030	19,214	35,756		1,409,000	1,172,929	.83	1,414	176
	6,963,180	264,492	258,614	55,570	7,541,856	6,303,994	.84	9,990	154
Small mines		130,048			130,048	171,894	1.32		
Grand total	19,821,392	586,864	495,313	458,105	21,361,674	21,494,008	1.01	27,960	186

Coal Produced in Kentucky in 1915 and 1916—Continued.

1916

County	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of Employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Eastern district:									
Bell	2,182,454	27,859	34,229		2,244,542	3,308	621	3,929	208
Boyd	74,179	9,229	2,173		85,581	139	49	188	232
Breathitt, Greenup, Knott, Lawrence and Lee	32,912	3,700	600		37,212	63	20	83	144
Carter	119,258	3,983	336		123,577	145	31	176	238
Floyd	851,158	8,149	14,146		873,453	772	157	929	197
Harlan	1,879,589	18,155	15,673	300,811	2,214,228	1,651	435	2,086	219
Jackson and Pulaski	4,985	5,023	156		10,164	16	7	23	200
Johnson	932,808	12,210	30,468		975,486	974	255	1,229	240
Knox	775,426	13,437	14,661		803,524	1,110	261	1,371	214
Laurel	86,803	120	715		87,638	200	18	218	165
Letcher	3,627,815	16,555	27,066		3,671,436	3,002	304	3,306	274
McCreary	654,340	9,950	1,000		665,290	898	93	991	256
Morgan	47,573	1,092	62		48,727	149	36	185	258
Perry	973,760	4,753	13,749		992,262	846	261	1,107	224
Pike	3,285,961	128,891	52,850	289,225	3,756,927	2,705	608	3,313	252
Whitley	869,108	13,650	22,670		905,428	1,519	269	1,788	197
	16,398,129	276,756	230,554	590,036	17,495,475	17,497	3,425	20,922	231
Western district:									
Christian	103,875	1,100	3,000		107,975	170	24	194	235
Daviess		59,335	520		59,855	63	12	75	240
Henderson	111,334	65,771	8,643		185,748	277	45	322	192
Hopkins	2,356,617	104,260	99,117	62,531	2,622,525	2,260	415	2,675	179
McLean	54,160	4,020	200		58,380	63	11	74	190
Muhlenberg	1,962,127	28,814	45,878		2,036,819	3,219	359	3,578	140
Ohio	428,339	33,966	22,635		484,940	1,073	105	1,178	112
Union	542,538	74,878	42,660		660,076	697	141	838	163
Webster	1,515,302	23,402	31,534		1,570,238	1,182	184	1,366	209
	7,074,292	395,546	254,187	62,531	7,786,556	9,004	1,296	10,300	162
Small mines[1]	1,000	110,966			111,966				
Grand total	23,473,421	783,268	484,741	652,567	25,393,907	26,501	4,721	31,222	208

[1]Includes Hancock County.

Value of Coal Produced in Kentucky in 1916.

County	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat	Made into coke at mines	Total value.	Average value per ton.
Eastern district:						
Bell	$2,907,611	$29,422	$34,253		$2,981,306	$1.33
Boyd	88,282	10,792	2,850		101,924	1.19
Breathitt, Greenup, Knott, Lawrence and Lee	46,590	4,875	875		52,340	1.41
Carter	171,229	5,175	361		176,765	1.43
Floyd	1,148,198	9,763	13,610		1,171,571	1.34
Harlan	2,495,767	31,995	18,991	$300,814	2,847,567	1.29
Jackson and Pulaski	7,929	5,525	140		13,594	1.34
Johnson	1,471,493	17,409	40,077		1,528,979	1.57
Knox	984,408	17,053	14,080		1,015,541	1.26
Laurel	93,122	130	745		93,997	1.07
Letcher	4,651,497	22,927	33,604		4,708,028	1.28
McCreary	660,470	13,978	2,000		676,448	1.02
Morgan	100,393	2,585	91		103,069	2.12
Perry	1,358,730	5,819	16,247		1,380,796	1.39
Pike	3,573,653	126,934	47,284	267,223	4,015,094	1.07
Whitley	1,349,174	25,624	29,184		1,403,982	1.55
	21,108,546	340,026	254,392	568,037	22,271,001	1.27
Average value per ton	1.29	1.23	1.10	.96	.127	
Western district:						
Christian	137,432	1,165	1,500		140,097	1.30
Daviess		76,638	568		77,206	1.29
Henderson	119,889	96,026	8,909		224,824	1.21
Hopkins	2,228,838	89,999	88,574	58,779	2,466,190	.94
McLean	70,584	4,040	200		74,824	1.28
Muhlenberg	2,083,637	33,665	36,172		2,153,474	1.06
Ohio	382,916	41,925	7,303		432,144	.89
Union	566,434	98,925	33,262		698,621	1.06
Webster	1,435,125	23,298	28,932		1,487,355	.95
	7,024,855	465,681	205,420	58,779	7,754,735	1.00
Average value per ton	.99	1.18	.81	.94	1.00	
Small mines[1]	1,750	165,561			167,311	1.49
Grand total	28,135,151	971,268	459,812	626,816	30,193,047	1.19
Average value per ton	1.20	1.24	.95	.96	1.19	

[1]Includes Hancock County.

Coal Produced in Kentucky, 1913-1916, In Net Tons

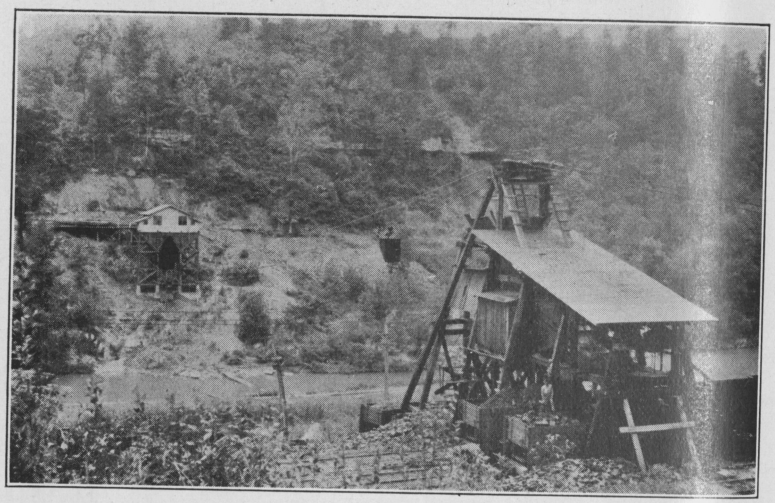
COUNTIES	1913	1914	1915	1916	Increase or decrease, 1916.
Eastern district:					
Bell	2,488,538	2,579,011	2,306,831	2,244,542	— 62,289
Boyd	131,208	92,882	78,000	85,581	+ 7,581
Breathitt, Greenup, Lawrence and Lee	105,396	[1] [2] 113,242	[2] 74,592	[2] 37,212	— 37,380
Carter	110,595	84,475	83,413	123,577	+ 40,164
Floyd	445,949	524,923	545,074	873,453	+ 328,379
Harlan	750,267	1,264,066	1,726,798	2,214,228	+ 487,430
Johnson	861,189	935,630	975,464	975,486	+ 22
Knox	961,492	904,684	767,713	803,524	+ 35,811
Laurel	196,569	101,205	85,136	87,638	+ 2,502
Letcher	[1]	1,427,626	2,229,334	3,671,436	+ 1,442,102
McCreary	625,101	586,541	569,535	665,290	+ 95,755
Morgan	90,346	76,028	58,815	48,727	— 10,088
Perry	24,953	221,012	547,962	992,262	+ 444,300
Pike	2,124,041	2,653,315	2,830,239	3,756,927	+ 926,688
Whitley	1,015,370	854,019	805,446	905,428	+ 99,982
Other counties[3]	1,107,833	3,100	5,418	[3] 10,164	+ 4,746
	11,038,847	12,421,759	13,689,770	17,495,475	+ 3,805,705
Western district:					
Christian	69,525	[4] 83,905	[4] 93,256	[4] 107,975	+ [4] 73,099
Daviess	48,543	47,538	42,778	59,855	+ 17,077
Hancock	6,280	7,000	4,000	[5]	[5]
Henderson	220,582	161,066	166,704	185,748	+ 19,044
Hopkins	2,534,821	25,551,720	2,332,143	2,622,525	+ 290,382
McLean	83,329	[4]	[4]	58,380	[4]
Muhlenberg	2,633,271	2,265,153	2,232,045	2,036,819	— 195,226
Ohio	775,545	660,273	519,820	484,940	— 34,880
Union	690,968	585,743	742,110	660,076	— 82,034
Webster	1,394,663	1,475,790	1,499,000	1,570,238	+ 121,238
	8,457,527	7,838,188	7,541,856	7,786,556	+ 248,700
Small mines	120,226	122,816	130,048	[5] 111,966	— 22,082
Grand total	19,616,600	20,382,763	21,361,674	25,393,997	+ 4,032,323
Total value	$20,516,749	$20,852,463	$21,494,008	$30,193,047	+$8,699,039

[1]No production in Greenup County.
[2]Includes Knott County.
[3]Other counties include Clay, Letcher and Pulaski in 1913; Clay, Pulaski and Rockcastle in 1914; Jackson and Pulaski in 1915 and 1916.
[4]Christian and McLean counties combined.
[5]Hancock County included in small mines.

The comparative output of the various coal producing counties in Kentucky for the calendar years 1917 and 1918, is as follows:

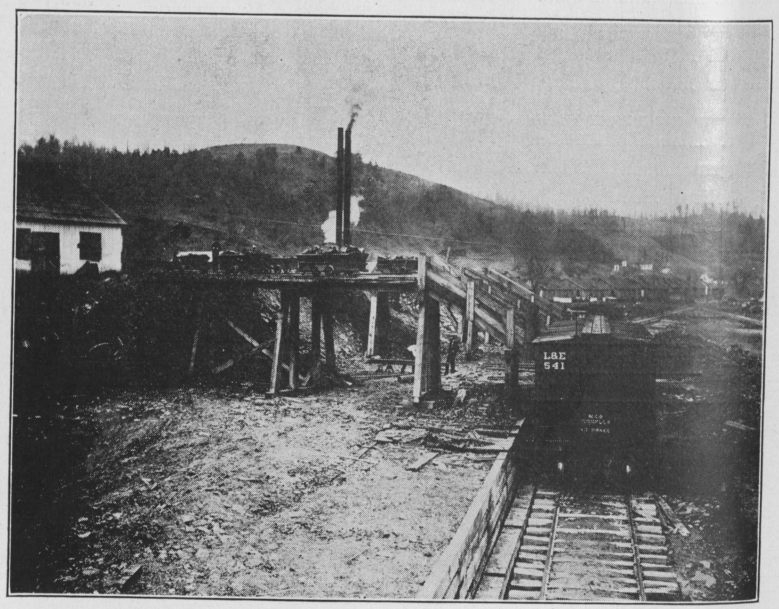
Calendar Year 1917	Tons
Pike	3,860,919
Letcher	3,627,102
Muhlenberg	3,230,854
Hopkins	3,037,748
Bell	2,963,459
Harlan	2,049,469
Perry	1,616,557
Webster	1,318,654
Union	963,559
Johnson	959,958
Ohio	877,206
Floyd	819,206
Whitley	813,563
McCreary	692,097
Knox	690,246
Henderson	254,148
Laurel	225,359
Carter	152,401
McLean	127,730
Boyd	107,145
Morgan	66,476
Christian	60,719
Daviess	57,839
Lawrence	38,272
Breathitt	37,982
Lee	26,074
Jackson	13,999
Clay	12,075
Hancock	9,160
	27,809,976

Calendar Year 1918	Tons
Pike	4,532,934
Fletcher	3,348,326
Muhlenberg	3,623,019
Hopkins	2,830,354
Bell	2,292,755
Harlan	3,176,856
Perry	2,201,178
Webster	1,464,508
Union	961,142
Johnson	869,932
Ohio	1,244,257
Floyd	1,004,631
Whitley	780,872
McCreary	754,316
Knox	720,114
Henderson	393,736
Laurel	393,087
Carter	187,739
McLean	174,321
Boyd	110,561
Morgan	51,103
Christian	85,861
Daviess	42,871
Lawrence	52,430
Breathitt	169,087
Lee	36,650
Jackson	9,124
Clay	12,333
Hancock	6,245
	31,530,442



A BUCKET TIPPLE.

The view is on the headwaters of the Russell Fork of the Big Sandy River, in Pike County. Many coal properties on the opposite side of the river from the railroad are now being operated in this way. Photo by W. R. Jillson. May, 1919.



A MORGAN COUNTY CANNEL COAL MINE.

Kentucky is famous for its production of high grade cannel coal and some of the best grades of this kind of coal comes from Morgan County. Floyd, Pike, Breathitt, Perry, Knox and several other counties also produce cannel coal. Photo by W. R. Jillson. 1918.

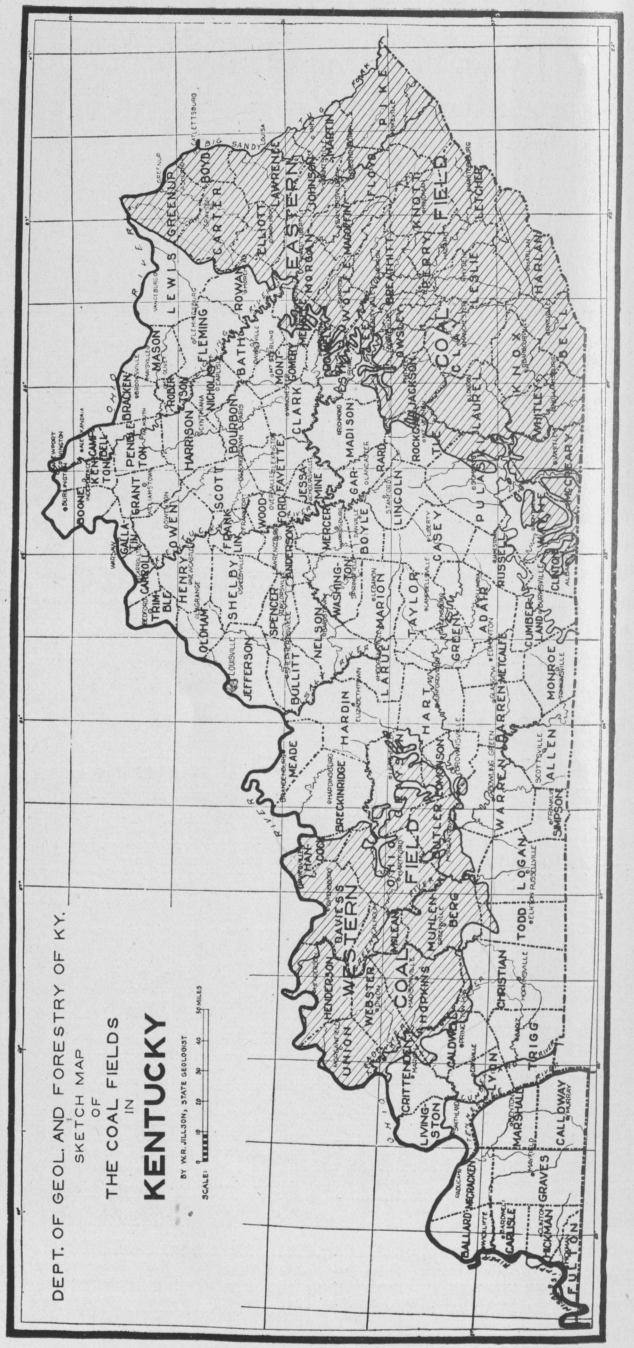
Coal Production by Districts

The production figures for the Eastern and Western Coal Fields during the past three years is as follows:

Field	1916	1917	1918
Western	7,727,428	9,937,617	.....
Eastern	17,565,339	17,872,359	.....

The 1917 coal production by counties in the three districts, Western, Southeastern and Northeastern, is as follows:

	Tons.
WESTERN DISTRICT	
Christian (incomplete)	60,719
Daviess	57,839
Hancock	9,160
Henderson	254,148
Hopkins	3,037,748
McLean	127,730
Muhlenberg	3,230,854
Ohio	877,206
Union	963,359
Webster	1,318,654
	9,937,617
SOUTHEASTERN DISTRICT—	
Bell	2,063,459
Clay	12,075
Harlan	2,049,469
Knox	690,246
Laurel	225,359
McCreary	692,097
Whitley	813,563
	6,546,268
NORTHEASTERN DISTRICT—	
Boyd	107,145
Breathitt	37,982
Carter	152,401
Floyd	819,206
Jackson	13,999
Johnson	959,958
Lawrence	38,272
Lee	26,074
Letcher	3,627,102
Morgan	66,476
Perry	1,616,557
Pike	3,860,919
	11,326,091



Statistics of Gains and Losses by Districts—1917

	Tons
Western District, gain	2,210,189
Northeastern District, gain	672,184
	2,882,373
Southeastern District, loss	365,164
Net gain	2,517,209

Statistics of Gains and Losses by Counties—1917

WESTERN DISTRICT—	Gain	Loss
Christian		41,349
Daviess	17,028	
Hancock		1,340
Henderson	84,576	
Hopkins	431,936	
McLean	55,248	
Muhlenberg	1,214,995	
Ohio	405,596	
Union	300,593	
Webster		257,094
	2,509,972	299,783
Less	299,783	
Net gain	2,210,189	

SOUTHEASTERN DISTRICT—	Gain	Loss
Bell		173,881
Clay	12,075	
Harlan		155,084
Knox		81,439
Laurel	148,038	
McCreary	19,347	
Whitley		134,220
	179,460	544,624
Less		179,460
Net loss		365,164

NORTHEASTERN DISTRICT—	Gain	Loss
Boyd	34,706	
Breathitt	25,157	
Carter	21,965	
Floyd	4,596	
Jackson	4,602	
Johnson		101,523
Lawrence	27,660	
Lee	19,451	
Letcher		189,957
Morgan	18,749	
Perry	621,466	
Pike	185,312	
	963,664	291,480
Less	291,480	
Net gain	672,184	
Aggregate gains		3,653,096
Aggregate losses		1,135,887
Net gain		2,517,209

THE WIER SAND—A NEWLY RECOGNIZED OIL HORIZON IN EASTERN KENTUCKY.

By Willard R. Jillson

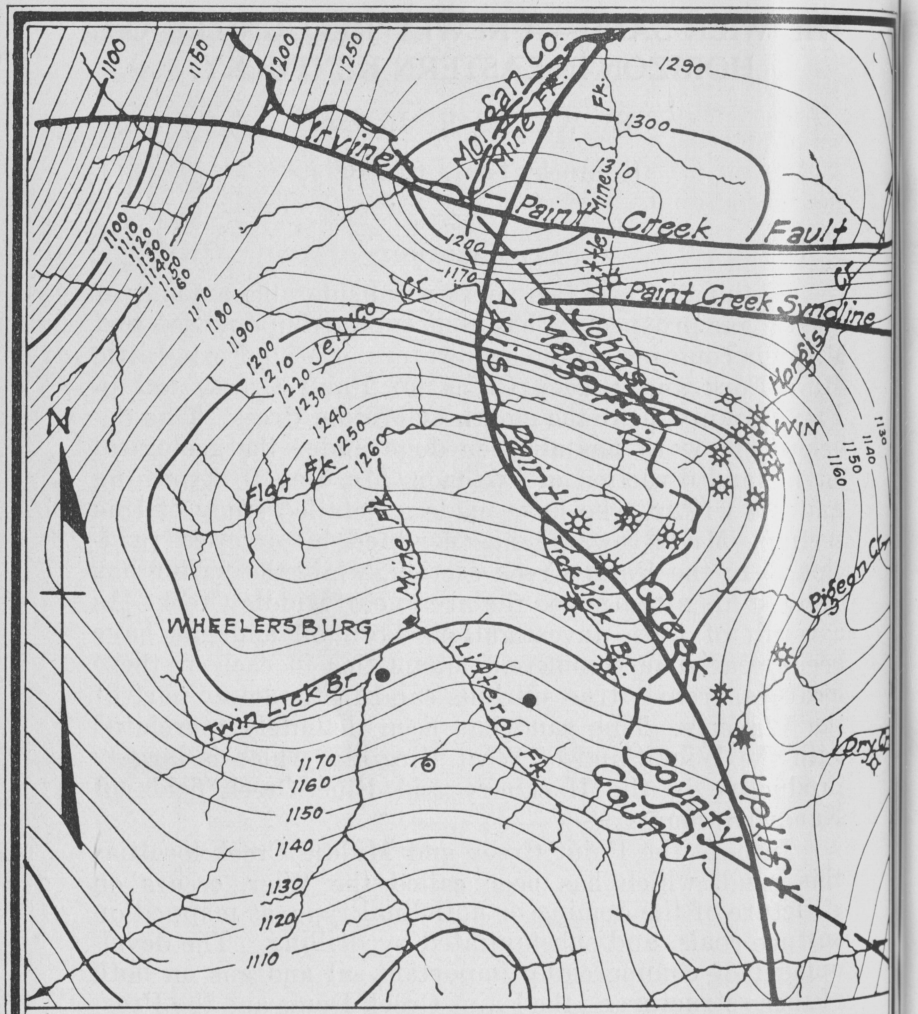
Kentucky State Geologist

Introduction

Within the last two years a considerable amount of oil and gas prospecting has gone forward in Johnson and Magoffin counties, on the headwaters of Mine Fork, Little Mine Fork and Pigeon Creek, of Paint Creek, and in Floyd county, near the mouth of Middle Creek. This development work has all been done under the geological advice and direction of two men, Mr. Iley B. Browning and the writer, who have made a detailed study of this section. Mr. Browning has confined his interest principally to the Paint Creek section, while the writer has devoted his attention to the area near Middle Creek. As a result of these investigations both oil and gas have been secured in commercial quantities in each of these localties, from a true silicious sand in the lower part of the Waverly. This sand has been definitely correlated with the Wier Sand of West Virginia, which is largely productive in the Hackbury and Blue Creek fields of Kanawha county.

In both the Paint Creek and Middle Creek localties this sand, which has been called the Wier, occurs on structure of the doming or anticlinal type, as mapped on surface coals, and substantiated by drilling. The development of commercially important oil and gas on both of these structures—the Paint Creek Dome and the Prestonsburg Anticline—operates as a splendid verification of the anticlinal theory of oil and gas accumulation, as it is now understood. The relative value of structure—the thickness and other lithological characteristics of the Wier Sand being the same—is also well demonstrated, since the larger oil and gas production of the Paint Creek Dome is directly in proportion to its superiority over the Prestonsburg Anticline in point of size and symmetry.

†Morse, W. C., and Foerste, A. F., The Waverlain Formations of East Central Kentucky. Ky. Geol. Surv. Series III, Bull. 16, 1912.



SKETCH MAP
SHOWING STRUCTURE AND WIER SAND PRODUCTION
ON
THE PAINT CREEK DOME
IN
JOHNSON AND MAGOFFIN CO'S., KY.
Prepared under direction of W. R. Jillson, State Geol. of Ky.
Field Geology by I. B. Browning.
Key Bed Fire Clay Coal.
Development Correct to October 1, 1919.
Scale: 0 1 2 Miles

The Paint Creek Dome shows a closed structural reversal of 80 feet to the north, an essentially closed reversal of 360 feet to the west, and 250 feet to the south. The structural fall to the southeast has not been determined, but is greater than that of any other direction, since this is the direction of the normal dip. The Wier Sand on the Paint Creek Dome is now producing 20,000,000 cubic feet of gas from thirteen wells, and one hundred barrels of oil from two wells, with one well producing both oil and gas not included.

The structure at Prestonsburg has been pierced by five wells, all of which produced oil, and two or three of which produced gas. The total oil production is somewhat less than one hundred barrels and the total gas production is less than 1,000,000 cubic feet. Though this amount of drilling on both structures has been completed, it is certain that neither the best locations, nor the full capacities of these structures have as yet been drilled. Besides the two structures above noted, the Wier Sand is also productive of oil and gas on the Laurel Creek Dome in northwestern Johnson county and Lawrence county. Various other points in Lawrence county are also productive of oil from the Wier, and new production has just been brought in from the same sand on the Ivyton Dome on the Arnett farm in Magoffin county.

Subsurface Stratigraphy

The Wier Sand has been referred to the lower part of the Waverly. As a matter of fact it is well toward the bottom of this important oil and gas subdivision of the Mississippian System, occurring from 235 feet (Boyd Conely No. 1, Magoffin county) to 457 feet (Middle Creek Coal Company No. 1, Floyd county) below the top of the St. Genevieve-St. Louis Limestone (Big Lime). It is undoubtedly a direct correlative and identical with the Cuyahoga Sandstone. The outcrop of this sandstone formation has already been described† as, "predominately even-bedded, argillaceous sandstones, alternating with shales." It is undoubtedly less shaly and more sandy under cover and in the productive localities.

STRATIGRAPHIC POSITION OF THE WIER OIL AND GAS SAND IN THE MISSISSIPPIAN SYSTEM OF EASTERN KENTUCKY

Series	Group	Sand
Mauch Chunk	Mauch Chunk	Maxon
St. Genevieve-St. Louis	Big Lime	Big Lime Sand
Waverly	Big Injun	Keener* Big Injun* Squaw*
	Cuyahoga	WIER
	Sunburry**	
	Berea	Berea Grit

*Only one of the three sands generally present.
**A black shale—non-productive.

The Wier Sand, as it is found by the bit, is generally a gray, mediumly fine grain, true silicious sandstone, varying in thickness in productive wells from 31 feet (Boyd Conely No. 1, Magoffin county) to 43 feet W. J. Conely No. 3, Johnson county). In Magoffin county the depth below the Big Lime in five wells on the Paint Creek Dome is as follows:

F. M. Blanton No. 3.....344 feet
F. M. Blanton No. 2.....326 feet
J. C. Cantrill No. 1.....324 feet
Boyd Conely No. 1.....235 feet

In Magoffin county, on the Ivyton Dome, south of the Paint Creek Dome, the following depth is established:

Harris Howard No. 1.....320 feet

In Johnson county two wells show the depth below the Big Lime to be as follows:

W. H. Conely No. 3.....340 feet
Leroy Adams Oil Co. No. 3.....449 feet
(Barnett's Creek)

In Floyd county these depths below the Big Lime are found, the Middle Creek Coal Company No. 1, at the mouth of Middle Creek, showing 457 feet, and the W. S. Harkins No. 1. on Trimble Branch, showing 455 feet. In the Hackbury and Blue Creek fields of Kanawha county, West Virginia, the Wier Sand is from 350 to 390 feet below the top of the Big Lime. The following thicknesses of sand have been determined.

Magoffin County:
F. M. Blanton No. 3.....38 feet
F. M. Blanton No. 2.....42 feet
J. C. Cantrill No. 1.....38 feet
Boyd Conely No. 1.....31 feet
Harris Howard No. 1.....40 feet

Johnson County:
W. H. Conely No. 3.....43 feet
Leroy Adams Oil Co. No. 3.....34 feet
(Barnett's Creek)

Floyd County:
Middle Creek Coal Co. No. 1.....38 feet
W. S. Harkins No. 1.....40 feet

The true position of the Wier Sand is immediately above the Black Sunbury Shale, which latter formation separates it from the Berea Grit, which is the bottommost formation in the Mississippian System. The actual subsurface stratigraphic position of the Wier Sand in the developed sections of Magoffin, Johnson and Floyd counties is given in the logs of seven productive wells, which are herewith presented.

MAGOFFIN COUNTY

LOG No. 1.

F. M. BLANTON—No. 2.

Bed Rock Oil Co. Well, on F. M. Blanton Farm on Big Branch of Ticklick Branch of Mine Fork of Little Paint Creek, in Magoffin County.
Elevation Surface 960 A. T.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Drift	0	6	
Slate	21	27	
Coal	1	28	
Slate	11	39	
Gray sand	51	90	
White sand	80	170	
White sand	65	235	Fresh water and strong show of oil.
Gray shale and slate	107	342	
White sand	53	395	
Shale and gray sand	10	405	
White sand	5	410	
MISSISSIPPIAN SYSTEM.			
Gray sand and lime	10	420	
Green shale	10	430	
Sand and blue shale	19	449	
White lime—Big Lime	61	510	Big Lime—460 ft. of casing.
Gray and blue shale	104	614	
Limy sand	161	775	
Gray sand	41	817	Weir. Gas from top to bottom. 987,000 cu. ft. of gas.
Black shale—Sunbury	15	832	

Time of drilling 8 days. Drilled by E. F. Henry.

LOG No. 2.

Bed Rock Oil Co's, J. C. Cantrill No. 1, on Ticklick Branch of Mine Fork, in Magoffin County.
Elevation Surface 955 A. T.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Drift		15
Sandstone	85	100
Sand and shales	100	200
Sandstone	110	310
Sandstone	2	312
Blue Clay	13	325
White sandstone	48	373

MISSISSIPPIAN SYSTEM.			
Blue clay	2	375	
Shelly lime and shales	42	417	
Blue clay	9	426	
White lime	78	504	Big Lime casing set at 440.
Gray shales	208	712	
Sandy lime	28	740	About 50,000 cu. ft. gas.
Black shale	10	750	
Gray sand	38	788	Weir sand gas from top to bottom, 850,000 cu. ft.
Sandy shales	31	819	

Rock Pressure 285.

LOG No. 3.

Bed Rock Oil Co's. Boyd Conley No. 1, on Ticklick Branch of Mine Fork in Magoffin County.
Elevation Surface 905 ft.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Drift and sand		50	
Sandstone	140	190	
Coarse white sand	80	270	Fresh water at 200
White sand	70	340	
MISSISSIPPIAN SYSTEM.			
Blue clay with sandy breaks	25	365	
White lime	20	485	Big Lime cased at 400.
Brown shales	155	640	
Slate	10	650	
Sandy lime	15	665	Some gas.
Green shale	35	700	
Gray sand	31	731	175,000 cu. ft. gas.
Black shale	12	743	
Gray sand	26	769	555,000 cu. ft. gas.

Rock Pressure 285.

JOHNSON COUNTY

LOG No. 4.

RED ROCK OIL CO., W. H. CONLEY No. 3.

On the Head of Pigeon Creek of Little Paint Creek.
Elevation surface 935.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Drift	0 to 12		
Shale—show black oil	58	70	
Sand—fresh water at 180	245	315	
Sandy shale	35	440	
MISSISSIPPIAN SYSTEM.			
Gray shale	10	450	
Line	8	458	
Shale, gray	5	463	
White lime	6	469	
Gray shale	10	479	
Lime	3	482	
Gray shale	3	485	
White lime	90	575	Big lime. Casing set at
Sandy lime	155	730	497.5.
Gray shale	40	770	
Sand	5	775	
Sand	5	780	212,000 cu. ft. gas.
Hard fine sand	5	785	
Black shale	40	825	
Gray sand	7	832	555,680 cu. ft. gas. (Wier)
Gray sand	8	840	681,120 cu. ft. gas (Wier)
Gray sand	8	848	823,970 cu. ft. gas. (Wier)
Gray sand	20	868	979,000 cu. ft. gas. (Wier)
Bue shaes	22	890	

Rock pressure 285 pounds.

LOG No. 5.

BARNETTS CREEK.

Lessee, Leroy Adams Oil Co. Casing Head Elevation 702 Ft.
Production 5 Barrels Light Green Oil.
Total Depth 1035 Feet.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Sandstone, Pottsville	460	460

MISSISSIPPIAN SYSTEM.		
Grey shale	10	470
"Mauch Chunk" "Big Lime," gas 490, St. Louis	69	539
Pale green to grey shaley sandstone, Waverly	369	908
"Sunberry" shale	11	919
"Wier" sand (oil 919-053)	34	953
Hard sandy shale—Berea	77	1030
DEVONIAN SYSTEM.		
Black shale	5	1035

FLOYD COUNTY

LOG No. 6.

MOUTH OF MIDDLE CREEK.

Strata	Thickness	Depth
Soil Conductor		16
PENNSYLVANIAN SYSTEM.		
Shale	94	110
Coal	1	111
"Sandy" shale	139	250
Coal	6	256
Sand	86	342
Shale	80	422
"Beaver" sand	128	550
Black slate	6	556
"Horton" sand, salt water at 560 ft	80	636
Sandy shale	191	827
MISSISSIPPIAN SYSTEM.		
"Maxon" sand	80	907
"Little" lime	24	931
"Pencil Cave"	2	933
"Big Lime," gas 6 5-8 casing 956 ft	113	1046
"Big Injun," small amount gas, top	159	1205
Lime shells	185	1390
"Weir" sand, gas and green oil from 1394	38	1428

Oil 30.55 Baume. Oil stood 200 feet high in well day after drilling into "Weir Sand." Log from A. Fleming, Manager, T. M. King, Driller.

LOG No. 7.

W. S. HARKINS FARM.
Trimble Branch.

Strata	Thickness	Depth
Alluvial Quicksand	40	40
PENNSYLVANIAN SYSTEM.		
Conglomerate shale, sand and lime	408	448
Top salt sand (gas 450)	5	453
Shale	35	498
Sand (water 670)	197	685
Lime	35	720
Sand, white, settling	30	750
Slate	50	800
Sand (oil and gas 800 to 812)	40	840
Shale, blue	79	919
MISSISSIPPIAN SYSTEM.		
"Maxon" sand	65	984
"Little Lime"	20	1004
"Pencil Cave"	3	1007
"Big Lime"	160	1167
Shells, sand and shale	257	1424
Brown shale	40	1464
"Berea" sand, (first) oil 1467-1480	40	1504
Shale, black	3	1507
"Berea" sand	40	1547
DEVONIAN SYSTEM		
Shale, black	148	1695
Shale, brown	20	1715
Sand, Gray	5	1720
Shale, black		1750
Bottom of hole		1750

Casing put in 12½, 40 feet.
Casing put in 8¼, 115 feet.
Casing put in 6⅝, 1017 feet.
Shot well from 1467 to 1482 feet with 60 qts. nitro-glycerine.
Shot cleaned well. Well filled up about 90 ft. within forty minutes after shot.
Contractor—King Drilling Co., Huntington, W. Va.

Subsurface Extent of the Wier Sand

With the determination of the Wier Sand as a newly productive horizon for both oil and gas in Eastern Kentucky, considerable attention has been paid to a study of its subsurface extent for the purpose of further prospecting. An examination of the well logs of the eastern, especially the central-eastern portion of Kentucky, has revealed the fact that the Wier Sand as it is now known is not a widely extensive subsurface strata. It can be definitely recognized in the records of the drilled wells in Boyd, Lawrence, Johnson, Magoffin, Floyd and Martin counties, and is also present in the northern part of Pike, and the eastern portions of Greenup, Carter, Elliott, Morgan and Breathitt.

A comparison of the thicknesses of this sand shows it to reach its maximum known thickness of about 64 feet in Lawrence, Boyd and Martin counties. It thins rapidly to the southwest and northwest to productive thicknesses of about 30 to 40 feet, and from this thins down to such small and unproductive thicknessess as to be generally insignificant and unrecognizable by the driller. In Boyd county in the Big Sandy Oil and Gas Company well near Cattlettsburg, on Catlett's Creek, the top of the Wier Sand is 1329 feet and the bottom is 1380 feet, giving a thickness of 51 feet. Oil shows were found in this well. In Elliott county, on the J. F. Dial's farm, near Isonville, the top of the Wier is 715 feet and the bottom 750 feet, giving a thickness of 35 feet. This well produced gas. On the Jess Peter's farm in Elliott county the top of the Wier is 783 feet and the bottom 836 feet, giving a thickness of 53 feet, a small part of which may not have been the Wier. Oil shows were encountered in this well. In Lawrence county the F. R. Bussey well, near Busseyville, shows the top of the Wier at 653 feet and the bottom at 717 feet, giving a thickness of 64 feet. The Jason Boggs, on Cane's Creek, shows the top of the Wier at 888 feet and the bottom at 952 feet, showing a thickness of 42 feet. The O'Brien Well, four and one-half miles south of Louisa, shows the top of the Wier at 1760 feet and the bottom at 1800 feet, giving a thickness of 40 feet.

A sketch map showing the known subsurface extent of the Wier Sand has been prepared and is included within this paper. The productive localities of the Wier have also been indicated by proper legending. The heavy dark line used to denote the geological limits of this sand must not be regarded as the actual line of pinching out of

the Wier in Kentucky. It is, however, that line along which the sand becomes too thin to be recognized by the driller. It is undoubtedly certain that as a thin stratigraphic leaf it extends considerably beyond this line before it actually pinches out entirely.

Summary

In summation, the Wier Sand has been definitely recognized and correlated as a new productive horizon of the Waverly in Eastern Kentucky. It is an extension

of the Wier Sand of West Virginia, which is largely productive of both oil and gas in Kanawha county. Stratigraphically, the Wier Sand correlates with the Cuyahoga but may be considered for drilling purposes a downward subdivision of the Big Injun Series and therefore, in Kentucky, as in West Virginia, a unit with the Squaw Sand, of the Big Injun Series, though separated by a definite shale. The subsurface extent of the Weir in Kentucky is not large, being confined principally to the Big Sandy and the upper waters of the Licking River drainage systems. The Wier Sand gives shows of oil in many scattered localities within this area, but is not known at present to be commercially productive outside of Magoffin, Johnson, Lawrence, Martin, Floyd and Pike counties. A single analysis of Wier Sand oil from the Middle Creek Coal Company No. 1 well, at Prestonsburg, is appended herewith for reference purposes. Partial volitalization of this sample prior to collection resulted in the small amount of the distillate below 150°.

Crude Petroleum Analysis

Laboratory No. G—3857. Petroleum labeled "Crude oil produced by the Great Central Company, Prestonsburg, from the Middle Creek Coal Co. No. 1 well at the mouth of Middle Creek, Floyd county, Ky. Collected by W. R. Jillson. October 29, 1918. From the "Weir Sand," 1425 feet. Sample had been exposed to air. Sample, a thick, green oil.

Specific gravity at 60° F., 0.877, equivalent to 29.6° Baume.	
Distilled below 150° C. (302° F.)	none
Distilled between 150° and 300° C. (302-572° F.)	32.8%
Thick, oily residue	66.7%
Total	99.5%

Began to distill at 166° C. (320° F.)

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter, Sept. 4, 1919.)

THE PAY OIL SANDS OF EASTERN KENTUCKY.

By Willard R. Jillson

Kentucky State Geologist

Introduction

Not a little has been written concerning the commercially important oil sands of Eastern Kentucky. The literature concerning the productive horizons of this important section of the state is, however, chiefly of that kind which is devoted to the exposition of particular areas and separate oil and gas pools. With a single exception*, no publication has ever attempted to present a summary study of all of these sands under one title. This, however, is the purpose of this paper. Sectional sketch maps are included herewith showing the areas in the eastern portion of this State, where the various sands outcrop, and the areas beneath which they may be found by the drill. The geologic data herewith presented is based on personal field work done by the writer during the years 1917-1918-1919, during which time practically every important portion of Eastern Kentucky has been covered at least one or twice and many sections more often. Added to this the writer presents such facts as are seemingly well established by a study of about 500 logs of various wells drilled for oil and gas in the eastern part of this state. The information herewith given is intended to be summary rather than fully detailed, the article being written especially for the practical oil man, who wishes to gain a comprehensive understanding of the stratigraphic sequence of this portion of Kentucky. The sands herewith discussed are taken up in descending order, that is, from the Pennsylvanian System down through, to and including the Ordovician System. This is the order of actual super-position, that is, the order in which they would be penetrated by the drill.

*Hoeing, J. B., The Oil and Gas Sands of Kentucky, Kentucky Geological Survey, Series III, Bulletin 1, 1919.

THE PENNSYLVANIAN SYSTEM

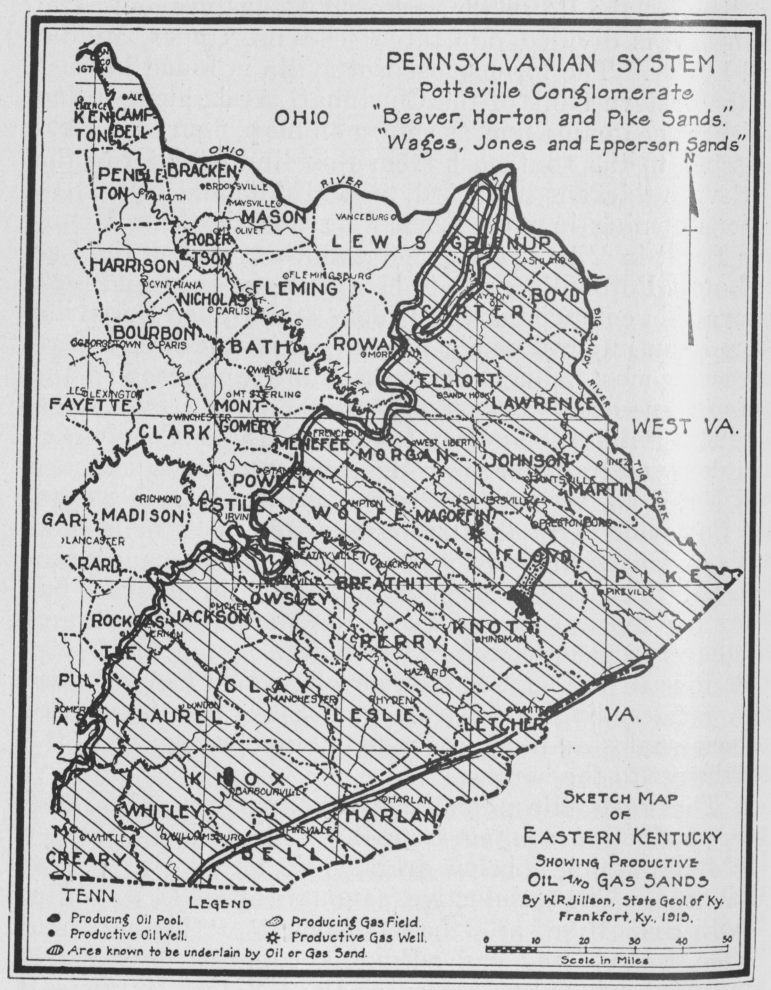
The Pottsville Conglomerate

The principal surficial rocks of Eastern Kentucky are those of the Pottsville or Lower Pennslyvanian. The Pottsville is divided into three sections, Upper, Middle and Lower. The lower-most Pottsville is found highest on the eastern flank of the Cincinnati Arch, along a line which is the double line, as shown on map, figure 1. Progressing to the southeast from this line of outcrop the Pottsville thickens immensely, the Middle and Upper Divisions coming in until when we reach the Pine Mountain Fault in Pike and Letcher counties, we find the Lee or Lower Pottsville alone to be about one thousand feet. Above this comprising the Middle and Upper Pottsville there is an interval of almost twice this thickness before the lower-most Alleghany sediments are reached in the top of some of the ridges.

The Pottsville is often spoken of as the Conglomerate, deriving its name from the conglomerate sandstones which appear towards its base. As a whole, however, the Pottsville is an alternation of sandstones, shales and coals and presents a very irregular sedimentary characteristic. The sandstones predominate throughout, but there are many sections where the shales are thick and frequently encountered. The thickening of the Pottsville toward the southeast is developed by the wedging-out or thickening of separate sandstones and the growth of new shales and new coals as one progresses from the northwest to the southeast.

The Pottsville is an important producer of oil and gas, production coming from three sands in the Lower Pottsville, which is below drainage in the central part of this area. The productive sands in Floyd, Magoffin, Knott and Pike are the "Beaver," "Horton" and "Pike." In Knox and adjoining counties three sands are found, which are known as the "Wages," "Jones" and "Epperson." These are probably the correlatives of the productive horizons to the northeast. The logs of three wells, two in Floyd county and one in Knox county, are given herewith to illustrate the stratigraphic sequence of the sands.

FIG. 1.



FLOYD COUNTY

LOG No. 1.

WELL RECORDS SHOWING POTTSVILLE SANDS, THE "BEAVER," "HORTON," AND "PIKE."

GEORGE ALLEN FARM.
Right Beaver Creek.

Strata	Thickness	Depth	
Drift	30	30	
PENNSYLVANIAN SYSTEM.			
Slate	12	42	
Coal	4	46	
Slate	18	64	
Gray sand	16	80	
Slate	23	103	
Gray sand	25	128	
Dark slate	25	153	
Light sand	22	175	
Dark slate	6	181	
Coal	3	184	
Dark slate	73	257	Pottsville
Light sand	36	293	
Slate	203	496	
Sand (Beaver)	246	742	
Light slate	6	748	
White sand (Horton)	165	913	
Coal	1	914	
Dark slate	5	919	
Gray sand	8	927	
Dark slate	58	985	
Sand (Pike)—Gas and oil	29	1014	
Dark slate	4	1018	
Gray sand (Base Pottsville)	13	1031	
MISSISSIPPIAN SYSTEM.			
Dark slate	4	1035	
Gray sand	10	1045	
Slate and red rock	8	1053	Mauch Chunk
Sand (Maxon) Gas and salt water	31	1084	
Black slate	45	1129	
Sand	50	1179	

LOG No. 2.

JAMES HICKS FARM.

Head of Brush Creek of Right Beaver Creek.

Strata		Thickness	Depth	
Soil		18	18	
PENNSYLVANIAN SYSTEM.				
Slate		21	39	
Gray sand		2	41	
Slate		15	56	
Gray sand		18	74	
Slate		26	100	Pottsville
Gray sand		10	110	
Slate		25	135	
Gray sand		112	247	
Slate		153	400	
Gray sand		12	412	
Slate		38	450	
Gray sand		25	475	
Sandy slate		73	548	
Sand—gas	(Beaver)	82	630	
Dark slate	(Beaver)	5	635	
White sand—gas	(Beaver)	54	689	
Dark slate		3	692	
White sand—salt water	(Horton)	127	819	
Coal and slate	(Horton)	2	821	
White sand	(Horton)	83	904	
Coal		1	905	
Gray sand		7	912	
Dark slate		38	950	
White sand (Pike)—Gas		69	1019	
MISSISSIPPIAN SYSTEM.				
Dark slate		30	1039	Mauch Chunk
Sand (Maxon)—Oil and salt water		115	1164	

LOG No. 3.

JOHN MARTIN FARM.

Right Beaver Creek.

Strata	Thickness	Depth	
Soil	25	25	
PENNSYLVANIAN SYSTEM.			
Slate	25	50	
Coal	3	53	
Slate	17	70	
Sand	51	121	
Slate	34	155	
Sand	55	210	
Slate	2	212	
Sand	29	241	
Slate	194	435	
Sand (Beaver)—Gas	219	654	
Coal	2	656	Pottsville
Slate	29	685	
Sand (Horton)	105	790	
Slate	3	793	
Sand	31	824	
Slate	3	827	
Sand	35	862	
Slate	35	897	
Sand (Pike)—Oil	56	953	
Slate	34	987	
Sand	10	997	
Slate	5	1002	
Sand (Base Pottsville)	18	1020	
MISSISSIPPIAN SYSTEM.			
Slate	29	1049	
Sand (Maxon)	67	1116	Mauch Chunk

From a structural standpoint the productive areas of the Pottsville, in Eastern Kentucky, are geo-synclinal, and the oil in the Knott-Floyd section is found in a local basin syncline as mapped on surface coals. A consideration of these facts leads to the conclusion that oil will later be found in important quantities in the Pottsville, except along that synclinal belt, which runs from Whitley, through Knox, Clay, Perry, Breathitt, Magoffin, Floyd and Pike counties. The factors which seem to favor the finding of oil along this line are thickness of the cover and thickness of the sand. To the northwest

the productive sands become thin, some of them rapidly, and the cover thins rapidly in the same direction. Towards the southeast these sands become quite deep, the base of the Pottsville being in some portions probably at least two thousand feet below the surface. On the other hand at some points, at least along the Pine Mountain Fault, radiating breaks or faults, and sharp crested anticlines have resulted in destroying the necessary cover and protection. Unbroken structure paralleling the Pine Mountain Fault should, however, prove productive upon systematic drilling.

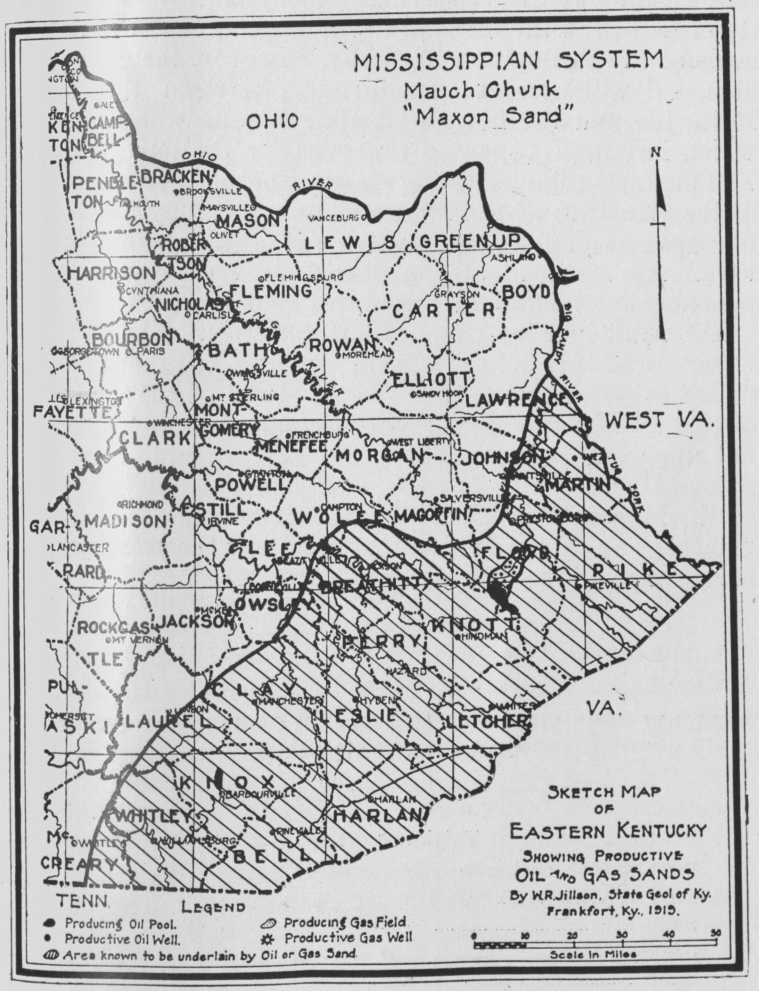
THE MISSISSIPPIAN SYSTEM

The Mauch Chunk

Unexposed at any point in Eastern Kentucky, except in a very narrow strip along the Pine Mountain Fault, the Mauch Chunk or upper-most division of the Mississippian System remained unannounced* as an important oil and gas producer of this section until the present year. It is now known that the Maxton Sand (corrupted by drillers to Maxon) is the principal producer of both oil and gas in Floyd county and the adjoining sections of Knott, in the Beaver Creek field. It is also an important producer in the Little Richland field, in Knox county. The geographic delimitations of the Mauch Chunk herewith presented have been obtained by a study of well logs, and it is believed that the northwestern boundary, as indicated on sketch map, Figure No. 2, is approximately the northwestern boundary line of the typical Mauch Chunk. From Lawrence to Breathitt county this line represents the discernible limit of the Mauch Chunk. From Breathitt county south to McCreary this line is one of transition from the typical Mauch Chunk (red and green and largely clastic) over into the more typical Chester Limestones and sands of light color.

*Jillson, W. R., The Status of the Mauch Chunk in Eastern Kentucky as a Producer of Petroleum and Natural Gas. Department of Geology and Forestry. Series V. Mineral and Forest Resources, Vol. 1, No. 2, 1919.

FIG. 2.



The Mauch Chunk is essentially an alternation of clastic sediments, which become more calcareous and show several bastard limestones toward the bottom of the group. The upper part is alternately shaly and sandy, the shales being either reddish, pinkish or green, and the sands tan to white. This coloration makes this horizon easily identified, either from drill samples or outcrops. The Mauch Chunk occupies essentially the south-

eastern limb of the Eastern Kentucky Geo-syncline, and its structure is theoretically similar to the overlying coals of the Pottsville. Actually, however, the considerable and widespread unconformity between the basal Pottsville and the Mauch Chunk introduces an error, which has been repeatedly proven by drilling records. The surface geology therefore may be used as an index to the structure of the Mauch Chunk, but may not be relied upon as an absolute reflector o fthe sub-surface structure. An instance of the departure from the rule is probably existent in the structural geology of the Beaver Creek field, in Floyd and Knott counties. The surface structure of this field is a basin syncline, but there is sufficient evidence procurable from a study of the well logs of this vicinity to suggest that irregularities of structure, not apparent at the surface, do exist at and above the principal producing horizon, which is the Maxton Sand of the Mauch Chunk. The logs of two wells in eastern Kentucky are given herewith to illustrate the stratigraphic sequence of the Mauch Chunk group.

LOG No. 4.

WELL RECORDS SHOWING THE MAUCH CHUNK AND THE MAXTON ("MAXON") SAND.

AKER BRANCH LEFT BEAVER CREEK

Strata	Thickness	Depth	
Drift 10 inch casing		44	
PENNSYLVANIAN SYSTEM			
Slate	36	80	
Sandstone	20	100	
Slate	120	220	
Sandstone	35	255	
Slate	100	355	
Sandstone	20	375	
Slate	125	500	Pottsville
Sandstone (Beaver)	190	690	
Sandstone	59	808	
Slate	10	818	
Sandstone	5	823	
Slate	12	835	
Sandstone	10	845	

MISSISSIPPIAN SYSTEM			
Red rock	18	863	
Slate	38	901	
Sandstone (Maxon)	51	952	
Limestone	6	958	
Slate	8	966	
Red rock	99	1065	
Slate, sandstone,	15	1088	
Slate	30	1110	Mauch Chunk
Limestone	10	1120	
Slate	10	1130	
Dark lime	77	1207	
Sandstone, (Gas)	33	1237	
Limestone, shale	33	1270	
White lime (Big Lime)	140	1410	St. Genevieve-St. Louis
Sand (Big Lime)	5	1415	
White lime (Big Lime)	19	1434	
Red Shale (Big Injun)	50	1484	
Slate (Big Injun)	47	1531	
Shale and sand	234	1765	
Brown shale	19	1784	
Sandstone "Wier"	45	1829	
Brown slate	150	1979	Waverly
Berea sand	21	2000	
Slate	2	2002	Total Depth

Note—Beaver sand showed gas at 537, oil and gas at 572, and unlimited saltwater at 660. Big Lime showed gas at 1396. Wier Sand showed "Amber" oil at 1784. Berea showed gas 1979-1994.

KNOX COUNTY

LOG No. 5. C. P. KENNEDY FARM.
East of Barbourville.

Strata	Thickness	Depth
Loam	38	38
PENNSYLVANIAN SYSTEM.		
Black sand	22	60
Coal	3	63
Black slate	7	70
Gray sand	15	85
Black slate	70	155
Coal	4	159
Black slate	6	165
Gray sand	21	186
Black slate	19	205
Gray sand—oil show at 210	35	240

Black slate	68	308	
Gray sand	27	335	
Black slate	15	350	
White sand—oil show at 385	95	445	Pottsville
Black slate	18	463	
Gray sand	107	570	
Black slate and shells	25	595	
White sand	75	670	
Black shale	10	680	
Black slate	40	720	
White sand — salt water at 743	43	763	
Black slate	37	800	
Brown sand	60	860	
Black shale	10	870	
White sand	105	975	
Black slate	47	1022	
White sand	15	1037	
Black slate	23	1060	
White sand (base of Pottsville)	15	1075	
MISSISSIPPIAN SYSTEM.			
Blue lime	15	1090	Mauch Chunk
Red rock	18	1108	
White sand	5	1113	
Red rock	32	1145	
Black slate and shells	63	1208	
Red rock	20	1228	
Blue slate	32	1260	
Brown sand—oil show at 1270 Maxon	26	1286	
Blue slate	24	1310	
Blue lime	15	1325	
Blue slate	65	1390	
Brown lime—gas show at 1395	12	1402	
White slate	10	1412	
White lime — "Big lime"—gas show at 1470	143	1555	St. Gen.-St. Louis
Slate and shells	260	1815	Waverly
Blue "flint"	15	1830	
Gray sand	55	1885	
White slate and shells	20	1905	

DEVONIAN SYSTEM.			
Black shale	145	2050	Chattanooga
White slate and shells	135	2185	
Pink slate	55	2240	
White slate	15	2255	
Red rock	25	2270	
Slate and shells	230	2500	

Note—The base of the Devonian System and the top of the Silurian cannot be marked as it is included in the 135 feet of white slate and shells just below 2050 feet.

THE ST. GENEVIEVE-ST. LOUIS LIMESTONES

The first and most easily recognized limestone horizon is that which is known as the Big Lime. This horizon has been separated by stratigraphers into two divisions, the St. Genevieve and the St. Louis Limestones. At most points in Eastern Kentucky these limestones are separated by a relatively thin layer of sandstone, which has become known as the Big Lime Sand. This sand parting between these prominent limestones is easily recognized in central and southeastern Eastern Kentucky, but is not so easily seen in northeastern Eastern Kentucky. The Big Lime itself varies in thickness from 35 feet on the outcrop in northeastern Kentucky to 250 feet in southeastern Kentucky, and 395 feet in Whitley county, the extreme southwestern portion of Eastern Kentucky. The Big Lime Sand is chiefly important as a gas horizon, being largely productive on the Warfield Anticline, in Martin county, and showing strong gas on the Yellow Mountain Anticline, in Knott county. Its line of outcrop is the double line as shown on the sketch map, Figure 3. While the surface structure of the western edge of the Eastern Coal field probably reflects the sub-surface structure of the Big Lime, due to the immense thickening of the Pottsville as one progresses to the southeast and the introduction in this same section of the irregular Mauch Chunk group, the Big Lime in the southeastern portion of Eastern Kentucky may not be regarded as conformable except to a very slight degree to the surface structure in this portion of the state. The counties in which the

FIG. 3.

Big Lime would therefore be out of accordance with the surface structure to the largest degree would be Pike, Letcher, Harlan and Bell, and to a lesser degree McCreary, Whitley, Knox, Clay, Leslie, Perry, Knott, Magoffin, Johnson, Floyd, and Martin. Five representative well logs have been introduced to show the sequence and position of the Big Lime in this section of the State.

ELLIOTT COUNTY

LOG No. 6.

WELL RECORDS SHOWING ST. GENEVIEVE-ST. LOUIS LIMESTONE, THE "BIG LIME" SAND.

J. F. DIALS FARM.

Isonville.

Strata	Thickness	Depth	
Quicksand	25	25	
PENNSYLVANIAN SYSTEM.			
Slate	115	140	
Sand	30	170	Pottsville
Slate—Cased at 180	10	180	
Dark sand	20	200	
MISSISSIPPIAN SYSTEM.			
Slate	40	240	
White lime — "Big lime"—Gas at 338	150	390	St. Gen.-St. Louis
Dark sand (Probably Big Injun)	15	405	Waverly
Slate and shell—Cased at 560	225	630	Waverly
Lime	40	670	Waverly
Gray sand—Gas at 715	80	750	Waverly
Slate	20	770	Waverly
Sand	95	865	Waverly
Slate and shell	29	894	Waverly
DEVONIAN SYSTEM.			
Black shale	376	1270	Chattanooga
White slate	77	1347	
SILURIAN SYSTEM.			
Sandy lime	35	1382	
Gas at 1348			
Strong gas at 1366.			
Bottom of well at		1500	

CARTER COUNTY

LOG No. 7 WELL NEAR DENTON.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Soil	5	5	
Quicksand	65	70	
Sand hard	80	150	
Shale	50	200	Pottsville
White sand	50	250	
Shale	50	300	
Sand (base of Pottsville)	20	500	

MISSISSIPPIAN SYSTEM.			
"Big Lime"	90	590	St. Gen.-St. Louis
"Waverly"	390	980	Waverly
Black shale (Sunbury)	90	1070	
"Berea sand"*	100	1170	
DEVONIAN SYSTEM.			
Black shale	500	1670	Chattanooga
Blue shale	100	1770	
"Clinton"*	70	1840	

*Driller's distinction, obviously incorrect.

Base of Devonian indefinite.

JOHNSON COUNTY

LOG No. 8.

THOMAS OSBORN FARM.

Toms Creek.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Soil	39	39	
Dark slate	126	165	
Gray sand	210	375	Pottsville
Dark slate	95	470	
White sand (base of Pottsville)	85	555	
MISSISSIPPIAN SYSTEM.			
"Big Lime"	159	714	St. Gen.-St. Louis
Dark sand	136	850	
Dark slate	170	1020	
Black slate	15	1035	
Gray sand	90	1125	
White slate	20	1145	Waverly
Black slate (Sunbury?)	35	1180	
Dark sand (Berea?)	30	1210	
DEVONIAN SYSTEM.			
Black shale	400	1610	Chattanooga
White slate	105	1715	
Lime	97	1812	

Base of Devonian indefinite.

CLAY COUNTY

LOG No. 9.

Nancy Potter, No. 1, on Blue Salt Run, a Branch of Goose Creek. 8 Miles west of Manchester. La Salle Oil Co., Operators. Elevation about 950 feet.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Soil	9	9	
Shell	3	12	
Gravel	6	18	
Sand	4	22	
Coal	5	27	
Dark shale	131	158	Pottsville
Hard sand	106	264	
Brown shale	10	274	
Sand	146	420	
Dark shale	40	460	
Light shale	25	485	
MISSISSIPPIAN SYSTEM.			
Red rock	15	500	
Slate	50	550	
Red rock	5	555	Mauch Chunk
Light shale	5	560	
Big lime	240	800	St. Gen.-St. Louis
Big Injun	55	855	
Red rock	7	862	Waverly
Dark shale	528	1190	
DEVONIAN SYSTEM.			
Black shale	135	1325	Chattanooga
Light shale	25	1350	
Black shale	10	1360	
Black lime	5	1365	
Brown shale	35	1400	
Gray lime, hard	15	1415	
SILURIAN SYSTEM.			
Blue slate	5	1420	
White slate	85	1505	
Red rock	5	1510	Niagaran
Blue slate	25	1535	
Dark sand	10	1545	
Green slate	115	1660	

ORDOVICIAN SYSTEM.

Brown lime	10	1670	
Green slate	25	1695	
Soft white lime	5	1700	
Green slate	10	1710	
Red rock	20	1730	
Green slate, very hard	12	1742	
Gray lime, hard	18	1760	
Slate and shells	20	1780	
Gray slate	50	1830	
Gray lime	20	1850	
Lime, shells, slate	25	1875	
Lime and flint with flakes of slate	15	1890	
Lime, flint	170	2060	
Gray lime	40	2100	
Lime and slate	60	2160	Trenton
Blue slate	30	2190	
Gray lime, dark	15	2205	

Note—The Big Lime shows gas at 700 feet. Gas was also secured at 1350 at the Onondaga horizon in the Devonian.

KNOTT COUNTY.

LOG No. 10.

ROCK FORK JUST BELOW BRUSHY FORK. W. R. BOLEN No. 1.
Lessee, Pennagrade Oil and Gas Co.

Completed July, 1916. Production 4,680,000 cu. ft. gas.
Producing Sand "Big Lime."

Casing Head Elevation 950 Aneroid. Total Depth 1635 feet.

Strata	Thickness	Depth
Drift 20 feet 10 inch casing		20

PENNSYLVANIAN SYSTEM.

White sand	5	25	Pottsville
Coal	5	30	
Dark slate	120	150	
Dark sand 8 inch casing	30	180	
Slate	5	185	
Sand	30	215	
Coal	5	220	
Slate	20	240	
Sand	70	310	
Slate	15	325	
Sand	95	420	
Slate	15	435	
Sand	45	480	
Slate	280	760	
Sand	148	908	
Break	2	910	
Sand (water at 950)	80	990	
Break	10	1000	
Sand (little oil at 1060 feet)	170	1170	
Slate	10	1180	
Sand	40	1220	
Shale	20	1230	
Sand	40	1270	

MISSISSIPPIAN SYSTEM.

Slate	30	1300	Mauch Chunk
"Maxon" sand (oil at 1305)	123	1423	
Black slate	14	1437	
Sandstone, light sandy	13	1451	
Slate and shells	25	1476	
"Little" lime	15	1491	
"Pencil Cave" shale	9	1500	
"Big Lime"			
Gas in Big Lime at 1630	135	1635	St. Gen.-St. Louis

4,680,000 cu. ft. gas, open flow 540 pounds Rock Measure.
Well completed July, 1916. Not shot.
1440 6 5-8 inch casing.
1637 2 inch tubing.
Elevation 945 feet.
A. B. Brode and Son, Contractors. S. L. Anderson, Driller.
135 feet is not the full thickness of the "Big Lime" formation.

WHITLEY COUNTY

LOG No. 11.

J. P. SHARP FARM.

Rockhold Station.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Soil	14	14	Pottsville
Black shale	36	50	
White lime	5	55	
Coal	1½	56	
Blue slate	88½	145	
White sand	10	155	
Black slate	30	185	
White sand	20	205	
Black slate	110	315	
Gray sand	190	505	
Black slate	40	545	
White sand	165	710	
Black slate	30	740	
White sand—oil show	230	970	
Black slate	35	1005	
Sand	26	1031	
Coal	2	1033	
Black slate	4	1037	
White sand	5	1042	
Black slate	15	1057	
MISSISSIPPIAN SYSTEM.			
White lime	5	1062	
Black shale	4	1066	
White sand	25	1091	
White shale	60	1151	Chester
White lime	54	1205	
White shale	50	1255	
White lime	30	1285	
White shale	5	1290	
White lime (Big lime)	265	1555	St. Genevieve-St. Louis
Brown sand	35	1590	
Blue sand	27	1617	
Blue shale	188	1805	
DEVONIAN SYSTEM.			
Brown shale	120	1925	
White shale	15	1940	Chattanooga
Brown shale	5	1945	

SILURIAN SYSTEM.		
White shale	60	2005
Red shale	5	2010
White shale	35	2045
Red shale	15	2060
White shale	5	2065
White lime	70	2135
ORDOVICIAN SYSTEM.		
Shale	70	2205
White lime	25	2230

FIG. 4.

THE WAVERLY GROUP

Directly underlying the St. Genevieve-St. Louis Limestone and in the lower part of the Mississippian System, as it is known in Kentucky, there is a series of several hundred feet of alternating limestones, shales and sandstones. This group is known as the Waverly in Kentucky. In West Virginia it is called the Pocono Group. The upper portion of the Waverly contains in descending order the Keener, Big Injun, and Squaw Sands, one or more of which are generally present, though it is very seldom if ever that the three are found in any one well. These three sands are intercalated between thick and rather easily identified red shales, known to the driller as red rock. Taken together these three sands are known as the Big Injun Group and are important productive horizons for both oil and gas in Eastern Kentucky. The principal production is secured in Martin, Pike, Johnson, Floyd, Breathitt, Clay and Knox counties. Figure 4 shows by sketch map the approximate northwestern limit of this group of petroliferous sands. This line is not a line of outcrop, but is one determined by a study of many well logs, two of which are presented herewith to show the sequence and depth of these sands.

FLOYD COUNTY

LOG No. 12.

WELL RECORDS SHOWING THE WAVERLY AND THE "BIG INJUN" SAND.

JOHN GRAY FARM.

Head of Bull Creek.

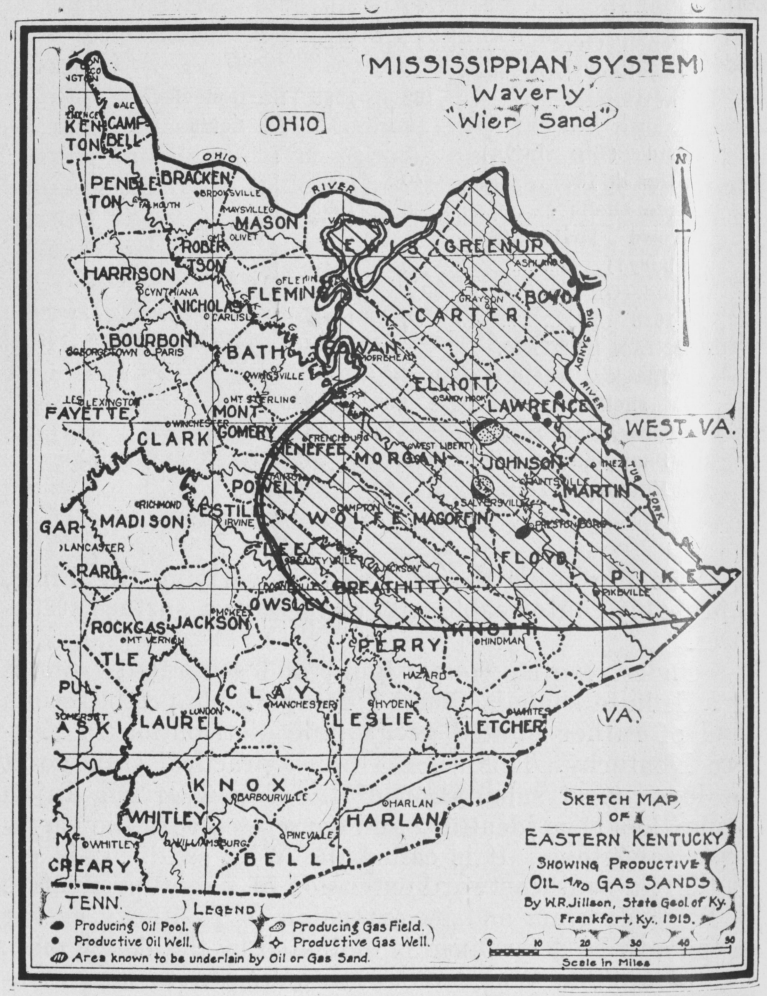
Strata	Thickness	Depth	
Gravel	14	14	
PENNSYLVANIAN SYSTEM.			
Sand and shale	26	40	
Coal	4	44	
Shale and shells	266	310	
Sand	90	400	
Shale and shells	100	500	
Sand (Beaver)—Gas at 610 water at 625	200	700	Pottsville
Shale	22	722	
Coal	2	724	
Sand—Water at 756..	72	796	
Slate and shell	50	846	
Sand	74	920	

MISSISSIPPIAN SYSTEM.			
Red shale	30	950	
Gray shale	41	991	Mauch Chunk
Sand (Maxon)	93	1084	
"Little lime"	24	1108	
"Pencil Cave"	15	1123	
"Big lime"—Oil show at 1190	162	1285	St. Genevieve-St. Louis
Sand (Big Injun)—Gas at 1300	40	1325	Waverly
Lime shells	268	1593	Waverly
Brown shale (Sunbury?)	20	1613	Waverly
Lime—Oil show at 1628	80	1693	Waverly
DEVONIAN SYSTEM.			
Black shale and shells	135	1828	
Gray slate	15	1843	
Shells and shale	576	2419	
Flinty lime	19	2440	

The Big Injun Series, like the overlying Big Lime, is probably conformable only to the larger surface structures.

Underlyingthe Squaw Sand and separated from it by a definite shale is found a recognizable petroliferous sand of rather limited geographic distribution in Eastern Kentucky. This sand, from a practical standpoint the lower-most subdivision of the Squaw or Big Injun Group, has been identified and correlated with the Cuyahoga Sandstone. It is called the Wier sand. It is essentially a southeastward extension of a sand productive in West Virginia and its extension in Kentucky as far as can now be determined is indicated by the sketch map, Figure 5. The Wier sand is now known to be an important oil and gas horizon in Kentucky. Further development and prospecting will reveal much more concerning it within the next few years. Two logs are herewith presented to show its stratigraphic position and depth.

FIG. 5.



MAGOFFIN COUNTY

WELL RECORDS SHOWING THE WAVERLY AND THE "WIER" SAND.

LOG No. 13.

F. M. BLANTON—No. 3.

Bed Rock Oil Co., on Big Branch of Ticklick Branch of Mine Fork in Magoffin County.

Elevation Surface 1025 ft.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Drift		24	
Slate	76	100	
Brown sand	40	140	
White sand	60	200	Pottsville
White sand	100	300	
Shale and slate	124	424	
Brown sand	11	435	
Brown sand	25	460	
MISSISSIPPIAN SYSTEM.			
Gray shale	10	475	
Blue shale and lime	30	505	
Blue shale	20	525	
White lime (Big Lime)	75	600	Waverly
Green sand and shales	269	869	
Light gray sand (Wier)	46	915	
Black shale	34	949	

Driller, E. F. Henry.

NOTE:—Wier sand gas gauged over 2,000,000 cubic feet.

LOG No. 14.

Harris Howard No. 1, Bed Rock Oil Co., Lessee; Meadow Branch of Licking River, just above the forks of the Branch up the Right Fork.

Elevation Surface about 940 ft.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Drift	26	26
Shale	34	60
Coal	3	63
Sand	104	167
Coal	3	170
Sand	5	185
Sand—black oil	10	195

Sand	80	275	Pottsville
Bluish shale	25	300	
Sand	20	320	
Shales	155	475	
Sand with gas	25	500	
White sand—show of oil	50	550	
Sand—salt water	20	570	
MISSISSIPPIAN SYSTEM.			
Shale	170	740	
White lime (Big Lime)	95	835	St. Genevieve-St. Louis
Shales	335	1160	Waverly
Sand (Wier)	90	1255	
Sandy lime	60	1310	
Black shale (Sunbury)	40	1350	
Yellow hard shale	40	1390	
DEVONIAN SYSTEM.			
Black shale	360	1750	
Gray shale	115	1865	
Gray lime	90	1955	

NOTE:—Salt water in Wier at 1170. The last gray lime 90 feet thick, may be the Onondaga. It produced 100,000 cu. ft. gas.

The lower-most and delimiting sand of the Waverly Group and the lowest formation in the Mississippian System in Kentucky is the Berea Grit, which underlies the northern part of Eastern Kentucky. Its southern extension is along a line similar to that shown on sketch map, Figure 6. The Berea a, representative producer of southeastern Ohio, has a considerable area of productivity in Eastern Kentucky. Due, however, to the fact that it pinches out to the south, the areas in which it will be found commercially important as an oil horizon have probably now been well ascertained and are in the counties of Lawrence, Elliott, Morgan and northern Magoffin, Johnson and Martin. Three logs are presented herewith to show the stratigraphic sequence and depth of this sand.

FIG. 6.

LAWRENCE COUNTY

WELL RECORDS SHOWING "BEREA" SAND

LOG No. 15.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Gravel	39	39	
Lime	11	50	
Slate	80	130	
Sand	55	185	
Slate	225	410	
Sand	20	430	Pottsville
Slate	45	475	
Sand	160	635	
Slate	5	640	
Sand	230	870	
Slate (base of Pottsville	10	880	
MISSISSIPPIAN SYSTEM.			
"Little lime"	20	900	
"Big lime"	150	1050	St. Genevieve-St. Louis
Slate	10	1060	
Shale	20	1080	
Sand	422	1502	
Black shale (Sunbury)	15	1517	
"Berea" sand—oil	15	1517	Waverly

BOYD COUNTY

LOG No. 16.

BIG SANDY OIL AND GAS CO. WELL,

Catletts Creek, 11½ Miles from Catlettsburg.

Strata	Thickness	Depth	
PENNSYLVANIAN SYSTEM.			
Clay and sand	36	36	
Sandstone	104	140	
Clay shale	100	240	Pottsville
Gray sand	30	270	
Shale	150	420	
Sand (base of Pottsville)	150	570	

MISSISSIPPIAN SYSTEM			
Limestone—"Big Lime"..	280	850	St. Genevieve-St. Louis
Black sand	100	950	Waverly
White sand—Salt water..	15	965	
Black sand	35	1000	
Black shale—Oil show	329	1329	
Sand—Oil	51	1380	
Black slate (Sunbury shale)	45	1425	
Brown sand (Berea)	15	1440	
Shale and sand (Berea)	5	1445	
DEVONIAN SYSTEM			
Black slate	130	1575	
White slate	40	1615	
SILURIAN SYSTEM.			
Slate and shale	180	1795	
Slate and shells	50	1845	Niagaran
Sand—Gas	5	1850	
Black slate	10	1860	
Black sand	15	1875	
Black sand and slate	3	1878	
Blue slate	12	1890	
Brown slate	7	1897	
Black slate	68	1965	
Black sand—Gas	9	1974	
Black shale	52	2126	

THE DEVONIAN SYSTEM

The Chattanooga Shale

The most easily recognized, relatively deep petroliferous horizon in Eastern Kentucky is the Chattanooga Shale, correlative in part or in whole to the Genesee and Ohio Black Shale. It is commonly known in Kentucky simply as the "Black Shale." Its outcrop is found along a general northeast southwest line, slightly removed to the northwest of the border of the Eastern Coal field, and is indicated by a double line on the sketch map, Figure 7. Though found at relatively shallow depth in the western part of the Eastern Coal field, the Black Shale, due to the normal dip of the sub-surface strata of Eastern Kentucky, rapidly falls into deeper levels, with the result that the great number of shallow wells which have been drill-

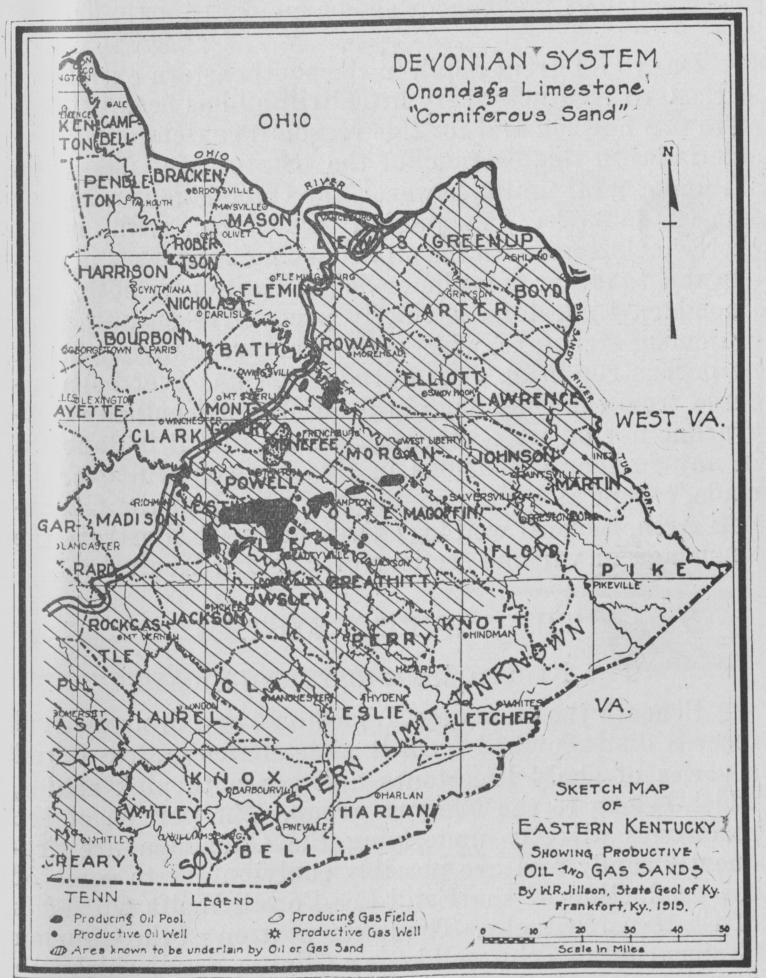
FIG. 7.

ed in southeastern Kentucky have never penetrated it. Its thickness varies from 20 feet to 250 feet. Though highly petroliferous and always gassy in streaks, the Black Shale may not be considered as an important oil horizon in Kentucky. On the Aker Branch of Left Beaver Creek, in Floyd county, however, there is a gas well drilled into a sand inclusion of the Black Shale at a depth of 2,002 feet, which is very productive, and it is possible

that other wells drilled into this sand lens will also be productive of gas. Generally, however, drilling to the Black Shale for production of gas should be discouraged on the basis of the large number of unproductive wells drilled to and through this horizon.

Directly underlying the Black Shale and probably generally conformable to it is found the Onondaga Limestone. This is what is known among drillers as the Corn-

FIG. 8.



iferous Lime or Sand and is the same as the Ragland, Menifee, Irvine, Cannel City and Campton Sands. It is the most highly productive oil horizon in Eastern Kentucky and the State. The Ragland, Olympia, Irvine, Ashley, Big Sinking, Station Camp, Ross Creek, Campton, Stillwater, Cannel City and other associated and less important oil pools secure their production from this horizon. The gas of the Menifee Gas field also comes from the Onondaga Limestone. The sub-surface extent of the Onondaga Limestone is shown on sketch map, Figure 8.

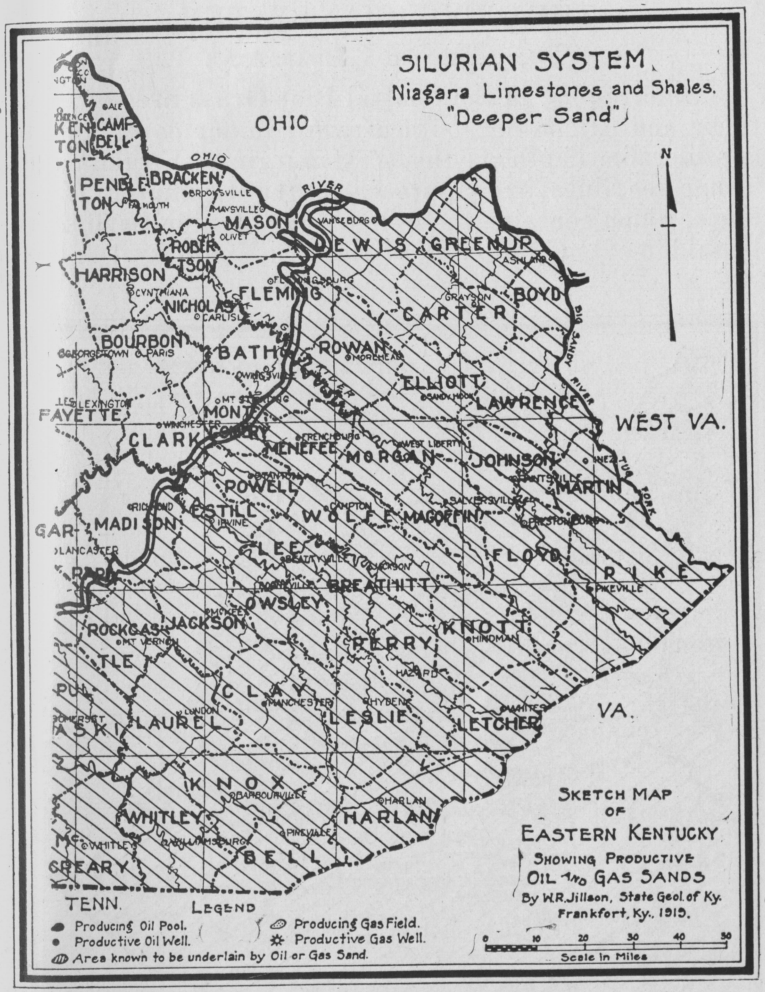
Due to its great depth in the southeastern extremity in Eastern Kentucky very little drilling has been extended to this horizon and for this reason its extent and characteristics in this section of the State are unknown. Within general limits, however, the Onondaga is a rather thin (25 to 45 feet) magnesian limestone, with many cherty inclusions. In the oil producing sections it is porous, due to either solution or dolomitization or both. The Onondaga Limestone is chiefly productive on anticlinal or doming structure, when such structure is accompanied by porous conditions. No production has ever been secured from the Onondaga in the Eastern Kentucky Geosyncline nor on its southeastern flank, and it is doubtful in any further extensions in this horizon will ever be made, except along the southeastern flank of the Cincinnati Arch. Several well logs given herewith illustrate the Onondaga in various sections of Eastern Kentucky.

THE SILURIAN SYSTEM

The Niagara Limestones and Shales

Beneath the Onondaga Limestone, and in many drill records distinguished from it with difficulty, are found a series of shaly limestones and green to pink shales, which belong to the Niagara group. The portion of the limestones directly underlying the Onondaga are frequently sandy and are possibly contributory to some of the production of the Estill-Lee-Powell-Wolfe Oil fields of Eastern Kentucky. The lower portion of the Silurian System contains the well known Clinton Sand, which is a limestone generally of reddish color and possesses the

FIG. 9.



flaxseed lithological characteristic. This limestone, productive elsewhere, has been the quest of much drilling in Eastern Kentucky, but has never been definitely shown to be of real commercial importance in this part of the State. The rocks of the Silurian System are penetrated by the drill frequently along the western border of the Eastern Coal field, but due to their depth are rarely touched in any other part of Eastern Kentucky and the horizon may not be considered in this part of the State as an important oil and gas producer.

THE ORDOVICIAN SYSTEM

The Lexington Limestone

Outcropping in the Central Blue Grass area of Kentucky and extending southeastward under cover and to considerable depth as the West Virginia, Virginia and Tennessee lines are approached, the Lexington Limestone, which contains the well-known Trenton Sand, may be said to extend under all of Eastern Kentucky. A con-

FIG. 10.

siderable number of widely separated deep wells have touched the Trenton horizon in this part of the State, but at no point has commercial oil or gas production been encountered. Its probable sub-surface extent is given on sketch map. Figure 10, but further discussion with respect to its lithology, etc., is here omitted, due to the fact that it is considered unimportant from an oil and gas producing standpoint in this part of Kentucky.

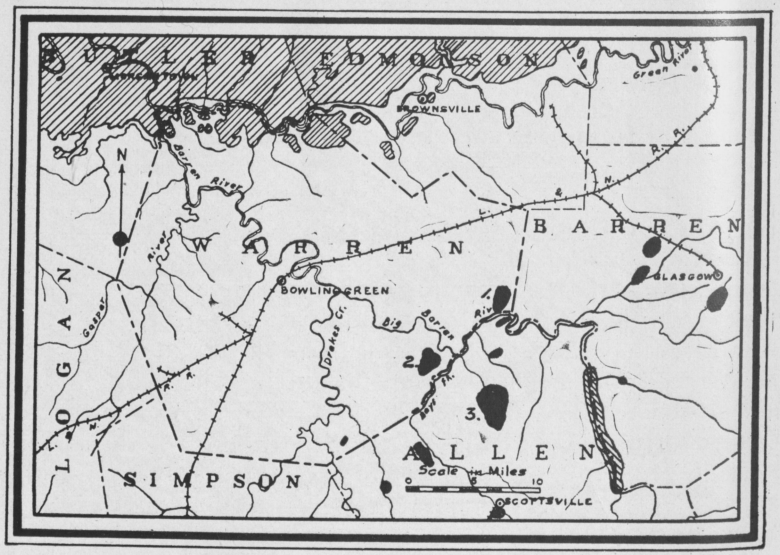
As the work of prospecting for oil and gas in Eastern Kentucky continues it is only reasonable to believe that much that is now unknown respecting the extent and productivity of the sequence of oil and gas sands herein discussed, will be brought to light. This new information will undoubtedly cause various changes to be made in the sub-surface extent of these sands as indicated on the accompanying maps. In making practical use of these maps it should be borne in mind that the area they cover is very large (about 18,000 square miles) and that the total of the included areas of known oil and gas geology is, in comparison, very small indeed.

THE NEW OIL AND GAS POOLS of WARREN COUNTY, KENTUCKY.

By Willard R. Jillson
Kentucky State Geologist

Location and Topography

Warren county is located in Southern Kentucky, in what is known as the "Pennyrile." Bowling Green, which is its county seat and largest town, is found in the central part of the county and is about ninety five miles in an air line slightly to the southwest of Louisville, Kentucky, and twenty-five miles to the north of the Tennessee line. Warren county is bounded on the north and northwest by Butler; on the north and northeast by Edmonson; on the east by Barren; on the southeast by Allen;



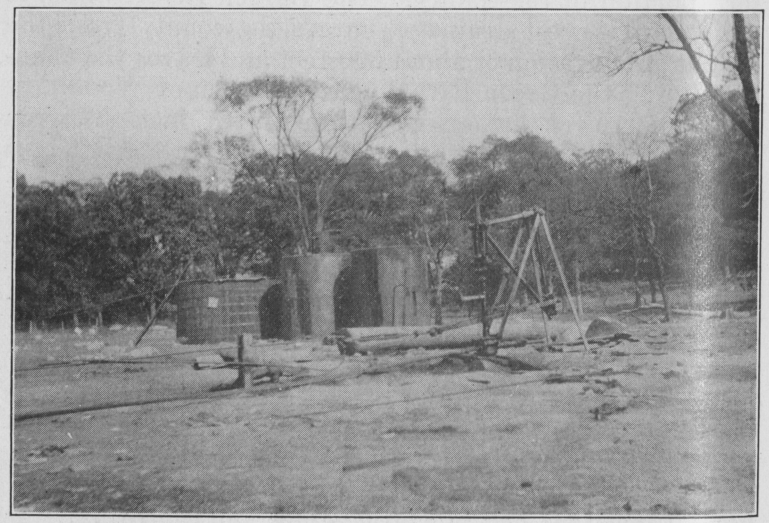
SKETCH MAP OF WARREN AND ADJOINING COUNTIES.
As shown above the principal Oil Pools of Warren County are: 1. The Moulder Pool; 2. The Green Hill Oil Pool. In Allen County there are a number of oil pools, the largest of which 3. is the Gainesville Pool. The hatchened areas in Warren County are Pennsylvanian, the light areas Mississippian.

on the south by Simpson, and on the southwest and west by Logan. Its area is about 563 square miles. The altitude of the surface of the county varies generally from 550 feet to 650 feet above sea level in the southeast, and from 450 feet to 750 feet above sea level in the northwestern portion of the county. The Barren River, which is the line of lowest drainage, enters the county from the east at an elevation of about 500 feet and leaves the county, joining the Green River, near the town of Woodbury to the northwest, at an elevation of 421 feet. Warren county, with the exception of small areas in the extreme northern portion where the coal measures overlap, is essentially a very imperfectly dissected, gently northwestward undulating table land, in which the large streams have incised themselves, giving a rolling effect. The only rugged topography is found along the Barren and Green Rivers and along the lower courses of their larger tributaries. The relief varies generally from 50 to 350 feet. The improved pikes of the county are located on the round ridges to avoid, in so far as possible, the imperfect drainage of a very large number of sink holes, which are conspicuously distributed throughout the St. Louis Limestone belt in southeastern and central portion of the county. The principal lines of drainage are the Green and Barren Rivers and their tributaries.

Acknowledgments

The material herewith presented represents a summation of such information as could be gathered from the publications of the former Geological Surveys of Kentucky, coupled with many personal notes collected by the writer while engaged in making many field examinations in Warren and adjacent counties during the years 1918 and 1919. During the year 1919 especially, Warren county has enjoyed the focussed attention of the oil prospecting public of this and adjoining states. The oil and gas development of this portion of Kentucky is now going forward so rapidly—twenty completions reported for the week ending November 1st—that it is almost impossible to present any report that is thoroughly up to date. It is the purpose of this publication, however, observing the limitations, to sketch in the main facts of the geology of

the oil and gas of Warren county, leaving the main amount of detail for a later and more comprehensive report. Thanks for many suggestions and much assistance in preparing this material are due to Mr. J. S. Kirby, Mr. C. A. Phelps and Mr. M. H. Crump, all of Bowling Green.

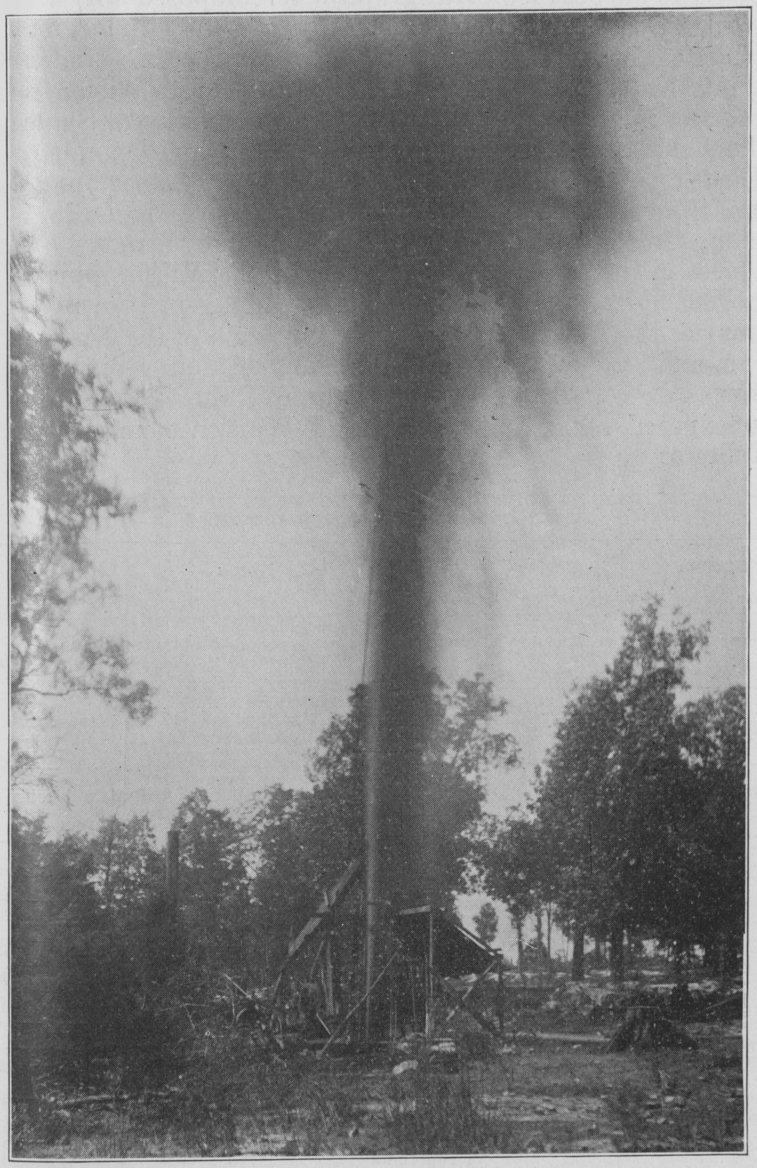


PUMP WELL COVINGTON NO. 1.

The production is shallow, being from the Waverly. The lease is located on the outskirts of Bowling Green. Photo by W. R. Jillson. September, 1919.

Stratigraphic Geology

The principal surficial rocks of Warren county belong to the Mississippian and Pennsylvanian Systems (See large sketch map). The Mississippian Rocks are chiefly limestones, the Gasper and St. Genevieve Oolites, the St. Louis and the Warsaw forming the principal exposures. At the top of the Mississippian System is found the Cypress Sandstone. The Pennsylvanian Rocks, clastics, are principally conglomerate sandstones, shales, and coals of the Pottsville. The Pennsylvanian exposures overlap a small area in the northern part of the county, the Mississippian, Cypress, Gasper, St. Genevieve, St. Louis and Warsaw formations covering in the same order the remaining and principal area as one progresses to the southeast.



SHOOTING THE HUNTER NO. 1.

This well is located about two miles west of Bowling Green, on the Morgantown Pike. It produced both oil and gas. Photo by W. R. Jillson. September, 1919.

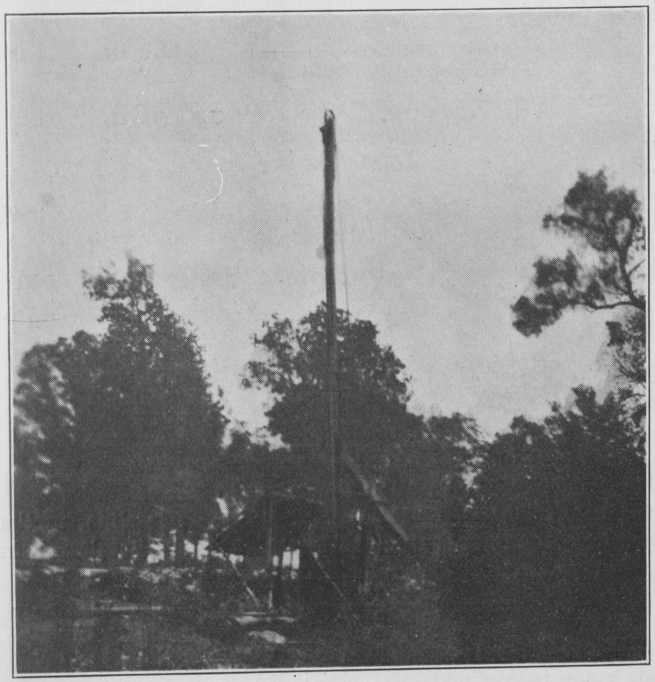
The subsurface stratigraphy is composed of the Fort Payne formation, essentially a chirty limestone, which is the basal member of the Mississippian. Underlying this formation is found the upper-most division of the Devonian, which is the Black or Chattanooga Shale. This shale is underlain by the Hamilton and Onondaga Limestone of the Devonian; the Niagarian Limestone of the Silurian, and the Trenton Limestone of the Ordovician. In descending order the productive "sands" are lenses in the Warsaw-Fort Payne, of the Mississippian; porous horizons in the Hamilton or Onondaga (Corniferous) of the Devonian, and sandy horizons in the Niagarian, and Trenton groups of the Silurian and Ordivician, respectively. A generalized section of the exposed and unexposed rocks and oil sands of Warren county is as follows:

MIDDLE PALEOZOIC SERIES IN WARREN COUNTY AND CORRESPONDING OIL SANDS

System	Series	Producing Sands	Notes	Lithology
Pennsylvanian	Pottsville	None	Exposed—Not productive	Sandstone, shale, coals
Mississippian	Chester	Big Lime	Exposed — Not a producer	Limestones
	Waverly	Fort Payne or Beaver Sand	Exposed partly Possible producer	Limestone
Devonian	Chattanooga	Stray Sands	Occasionally gas	Black Shale
	Hamilton Onondaga	Moulder Gainesville Rodemer Boyds Creek Scottsville	The principal oil and gas producing horizons in Allen county and vicinity.	Cavernous Limestone
	Niagara			Sandy, impure Limestones
Silurian	Clinton	Deep Sands	Very occasional producer	Limestones and Shales
Ordovician	Cincinnatian	Uper Sunnybrook Deep Sand	Very occasional producer	Mostly Limestones
	Mohawkian	Trenton Deep Sands	Very occasional producer	Mostly Limestones

The Producing Oil Sands

While there are certainly four horizons, the Warsaw-Fort Payne, in the lower Mississippian; the Hamilton-Onondaga (Corniferous), in the Devonian; the Niagaran of the Silurian; and the Trenton of the Ordovi-



SHOOTING THE HUNTER NO. 1.
Photo by W. R. Jillson. September, 1919.

cian, this number of sands may for all practicable purposes be reduced to one, the Onondaga (Corniferous), directly underlying the Black Shale, which is the principal oil horizon. At least ninety-five per cent of the wells designated as producers find some if not their principal production in this horizon, though there are a large number of wells, especially in central Warren county, which have obtained small high grade production from the "sands" of the Warsaw and Fort Payne. The production secured from this latter group of Mississippian Rocks is generally very light in gravity and in thin films

frequently shows an amber color, from which fact it has taken the name, "Amber Oil." The production secured below the Black Shale in the Onondaga (Corniferous) limestone is green crude, with a gravity ranging from 30 to 38 Baume'. Herewith are included five analyses of crude oil taken by the writer from various localities in Warren county.

Analyses of Warren County Oil.

Analysis No. 1.

Laboratory No. G-3864—Petroleum, labeled "(d) Green oil—Maj. R. W. Covington, No. 1, 355 feet, above shale, 1-2 mile Southeast of Bowling Green, Warren Co., Ky., Sept. 15, 1919. Collected by W. R. Jillson, Sept. 14, 1919."

Received from W. R. Jillson, State Geologist, September 15, 1919.

ANALYSIS

Specific gravity at 60° F., 0.854, equivalent to 33.9° B.		
Distilled below 150° C. (302° F.)	13.0%	(Gasoline fraction)
Distilled from 150 to 300° C. (302-572° F.)	36.5%	(Burning oil fract.)
Tarry residue	50.0%	
Loss in analysis	0.5%	
	100.0%	

The oil began to distil at 75° C. (167° F.)

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter)
Lexington, Ky., September 19, 1919.

Analysis No. 2.

Laboratory No. G-3861—Petroleum labeled "(a) Lessor (Dr.) Hunter. Lessee, Duplex Oil Co., 3 miles west of Bowling Green, Warren County, Ky. 960 feet below shale."

Received from W. R. Jillson, State Geologist, September 15, 1919.

ANALYSIS

Specific gravity 0.834° at 60° F., equivalent to 37.9° B.		
Distilled below 150° C. (302° F.)	20.2%	(Gasoline fraction)
Distilled from 150° to 300° C. (302-572° F.)	32.0%	(Burning oil fraction)
Thick, brown tar	45.0%	
Loss in analysis	2.8%	
	100.0%	

The oil began to distill at 65° C. (149° F.)

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter)
Lexington, Ky., September 19, 1919.

Analysis No. 3.

Laboratory No. G13862—Petroleum labeled "(b) Green oil from J. A. Hamel & Co., Wayne O'Neil, lessee, 1-2 mile northeast of Bowling Green, Warren County, Ky. Oil horizon, Onondaga and Niagara limestones. Depth 850 feet. Collected by W. R. Jillson, September 14, 1919"

Received from W. R. Jillson, State Geologist, September 15, 1919.

ANALYSIS

Specific gravity at 60° F., 0.856, equivalent to 33.6° B.		
Distilled below 150° C. (302° F.)	14.5%	(Gasoline fraction)
Distilled from 150° to 300° C. (302-572° F.)	34.5%	(Burning oil fraction)
Tarry residue	50.5%	
Loss in analysis	.5%	

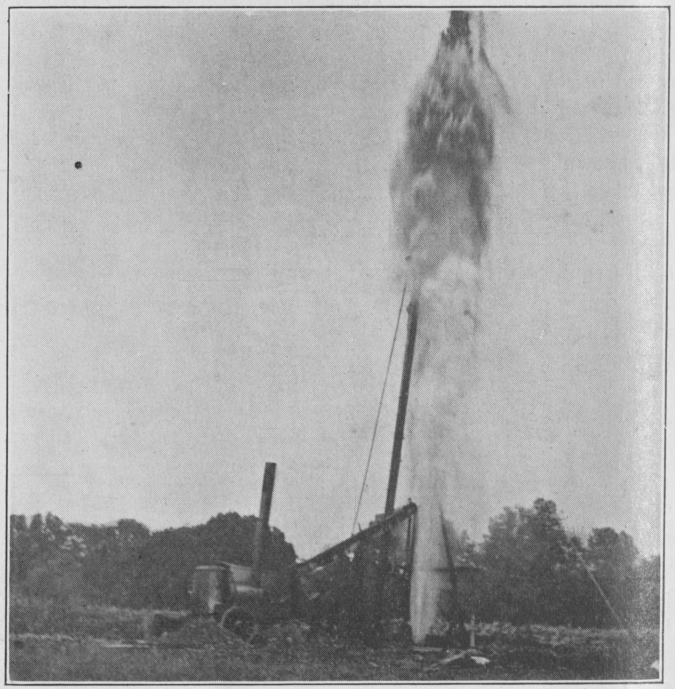
The oil began to distill at 65° C. (149° F.)

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter)
Lexington, Ky., September 19, 1919.

Analysis No. 4.

Laboratory No. G-3863—Petroleum labeled "Green oil, open steel tank. Horace Bohon No. 1. A Goldstine,



SHOOTING THE HAMILTON NO. 1.
Photo by W. R. Jillson, September, 1919.

lessee. 840 feet below shale. 1 mile east of Bowling Green, Warren County, Ky. Collected by W. R. Jillson, September 14, 1919."

Received from W. R. Jillson, State Geologist, September 15, 1919.

ANALYSIS

Specific gravity 60° F., 0.856, equivalent to 33.6° B.		
Distilled below 150° C. (302° F.)	13.0%	(Gasoline fraction)
Distilled from 150° to 300° C. (302-572° F.)	36.5%	(Burning oil fraction)
Tarry residue and loss, by difference	50.5%	
	100.0%	

The oil began to distill at 70° C. (158° F.)

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter)
Lexington, Ky., September 19, 1919.

Analysis No. 5.

Laboratory No. G-3865—Petroleum, labeled "Fresh, green oil, Joe B. Sumpter, No. 1, Mrs. Gray, lessee, 1-2 mile west of Bowling Green, Warren County, Ky. Oil at 880-900 feet, total depth 920 feet. Oil horizon, Niagara. Collected by W. R. Jillson, Sept. 14, 1919."

Received from W. R. Jillson, State Geologist, September 15, 1919.

ANALYSIS

Specific gravity at 60° F., 0.865, equivalent to 31.9° B.		
Distilled below 150° C. (302° F.)	9.3%	(Gasoline fraction)
Distilled from 150° to 300° C. (302-572° F.)	37.5%	(Burning oil fraction.)
Tarry residue	52.5%	
Loss in analysis	0.7	
	100.0%	

The oil began to distill about 80° C. (176° F.)

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter)
Lexington, Ky., September 19, 1919.

Analysis No. 7.

Laboratory No. G-3879—Petroleum, labeled "Fresh natural flow of amber crude oil from the Jim Britt farm —Waverly sand—Warren County, Ky. Collected by W. R. Jillson, State Geologist, November 9, 1919." Sample, a thin, amber colored oil having a strong green fluorescence. When the bottle was uncorked a few small gas bubbles appeared in the liquid (temperature about 80° F.).

Specific gravity, 0.810, equivalent to 44.8° B.		
Distillate below 150° C. (302° F.)	25.0%	Gasoline fraction
Distillate from 150° to 300° C. (302-572° F.)	38.8%	Burning oil fraction
Pasty, green residue	34.4%	
Loss in analysis	1.8%	
Total	100.0%	

Began to distil at 40° C. (148° F.)

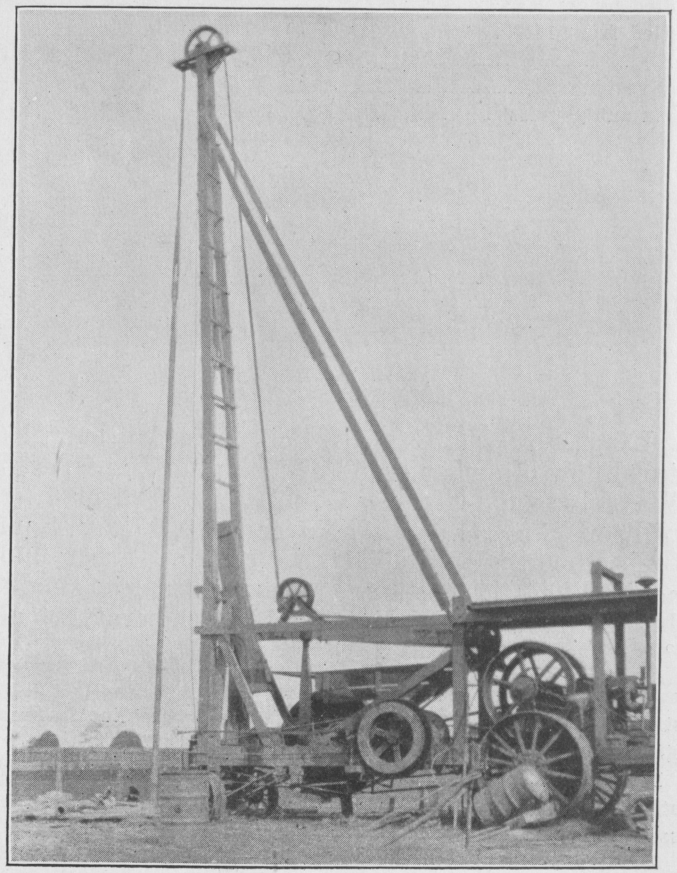
The residue after distillation still retained the strong, green fluorescence of the original oil. It partly solidied on cooling, apparently from the separation of solid paraffin.

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter)
Lexington, Kentucky, November 13, 1919.

Analysis No. 8.

Laboratory No. G-3880—Petroleum labeled "Fresh pumping olive-green crude oil from Sam Thomas heirs'



THE BOWLING GREEN FAIR GROUNDS DRILLING.
The location is in the southeastern limits of the city, between the Covington and Bohon properties. Photo by W. R. Jillson. September, 1919.

lease, Waverly sand, Warren County, Ky. Collected by W. R. Jillson, State Geologist, November 9, 1919." Sample a thin, green oil, dark brown by transmitted light.

Specific gravity, 0.844, equivalent to 35.9° B.		
Distillate below 150° C. (302° F.)	20.0%	Gasoline fraction
Distillate from 150° to 300° C. (302-572° F.)	33.8%	Burning oil fraction
Thick, brown, oily residue	46.2%	
Total	100.0%	

Began to distil at 68° C. (199° F.)

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter)
Lexington, Kentucky, November 13, 1919.

Analysis No. 9.

Laboratory No. G-3881—Petroleum labeled "Fresh natural flowing crude green oil from Albert Covington lease, Warren County, Ky. Waverly sand producing. Collected by W. R. Jillson, State Geologist, Nov. 11, 1919." Sample a pint of thin, green oil, received November 24, 1919.

Specific gravity 0.8815, equivalent to 34.4° B.		
Distilled below 150° C. (302° F.)	14.5%	Gasoline fraction
Distilled between 150° and 300° C. (302-572° F.)	38.5%	Burning oil fraction
Green and brown, thick residue	46.5%	
Loss in analysis	.5%	
Total	100.0%	

Began to distil at 70° (158° F.)

ALFRED M. PETER, Chief Chemist.

Lexington, Kentucky, November 26, 1919.

Analysis No. 10.

Laboratory No. G-3888.—Petroleum labeled "Green crude oil, Glen Lily Tract, C. L. Goodrum lease, 1 mile west of Bowling Green, Warren County, Ky. Collected by C. H. Scott, Jan. 1, 1920." Sample, thin, green oil,

dark brown by transmitted light. Forwarded by W. R. Jillson, State Geologist, for analysis.

Supecific gravity 0.848, equivalent to 35.1° B.

Distilled below 150° C. (302° F)	21.5%	Gasoline fraction.
Distilled 150 to 300° C. (302-572° F)	33.8%	Burning oil fraction.
Thick green-brown tar	44.4	
Lost in analysis	.3%	
	100.0	

Began to distill at 55° C. (131° F)

ALFRED M. PETER, Chief Chemist.

(Analysis by A. M. Peter.)
Lexington, Ky., Feb. 6, 1920.

Production of Crude Oil

MOULDER OIL POOL

Pipeline Runs, Swiss Pipeline Company

August*, 1919	10,672.41	Barrels
September, 1919	6,217.09	Barrels
October, 1919	3,306.90	Barrels
November, 1919	3,210.70	Barrels
December, 1919	2,327.59	Barrels
	25,734.69	Barrels

*No oil was run previous to August, 1919.

WELL RECORDS

The subsurface stratigraphy and depths to the various oil horizons are perhaps best understood through a study of the logs of wells drilled in various localities. To facilitate such investigations as the reader may wish to make, there are presented herewith records, which are considered representative of Warren county. These wells are presented by pools and unaltered from the original figure, which is given in feet.

LOG No. 1. MOULDER OIL POOL

Moulder No. 2.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Limestone	260	260
DEVONIAN SYSTEM.		
Black Shale	50	310
"Sand"	18	328
Limestone	180	508

Dry

LOG No. 2.

Moulder No. 4.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Limestone	261	261
DEVONIAN SYSTEM.		
Black Shale	45	306
"Sand"	15	321

Oil Flowing

LOG No. 3.

April 26, 1919
B. G. Goodnight No. 1.
(Opposite Moulder)

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Limestone	295	295
DEVONIAN SYSTEM.		
Black Shale	52	347
"Sand" (Dry)	18	365
Limestone	37	402
"Sand"	13	415

Oil Show

LOG No. 4.

Moulder No. 3

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Limestone	242	242
DEVONIAN SYSTEM.		
Black Shale	50	292
"Sand"	13	305

Oil Flowing

LOG No. 5.

April 26, 1919
Moulder No. 5.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Limestone	252	252
DEVONIAN SYSTEM.		
Black Shale	50	302
"Sand"	18	320

Oil Show

LOG. No. 6.

Salt Water
Jewell No. 1.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Limestone	225	225
DEVONIAN SYSTEM.		
Black Shale	50	275
"Sand"	15	290

Oil

LOG No. 7.

R. B. Osborn No. 1.
(2,000 ft. west of Jewell)

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Limestone	237	279
Black Shale	42	279
"Sand"	11	290
Limestone	58	338

Salt Water

GREEN HILL OIL POOL
Authority, W. H. HOGE

LOG No. 8.

Moody No. 1.

	Feet
Top of shale	366
Bottom of shale	416
Bottom of cap rock	426
Bottom of first sand	433
Soft blue lime	
Top second sand	451
Bottom second sand	472

7 or 8 hundred thousand feet gas in Green Shale.

LOG No. 9.

Moody No. 2.

Top of shale	364
Bottom of shale	417
Bottom of cap rock	428
Bottom of first sand	439
Gray limestone	
Top of second sand	450
Bottom of second sand	470
Blue lime to	480⅔

Considerable Gas.

LOG No. 10. Moody No. 3.

Strata	Feet
Top of shale	361
Bottom of shale	414
Bottom of cap rock	424
Bottom of first sand	428
Soft blue lime	
Top of second sand	441
Bottom of second sand	461
Blue lime	
Top of third sand	511
Bottom of third sand	519
Top of fourth sand	558
Bottom of fourth sand	562
Total depth well	579

Small amount of gas.

LOG No. 11. Motley No. 1.

Strata	Feet
MISSISSIPPIAN SYSTEM.	
Soil	19
Water	70
Sulphur	115
Cased	143
Green shale	250
DEVONIAN SYSTEM.	
Black shale	305
Cap rock	358
Sand	370
Brake	390
Sand	420
Brake	430
Sand	510
Whole	520

LOG No. 12. Motley No. 2.

Strata	Feet
MISSISSIPPIAN SYSTEM	
Soil	18
Water	65
Sulphur	108
Cased	120
Green shale	240
DEVONIAN SYSTEM	
Black shale	286
Cap rock	338
Pay	350
Whole	351

LOG No. 13.

Motley No. 3.

Strata	Feet
MISSISSIPPIAN SYSTEM.	
Soil	19
Water	64
Sulphur	106
Cased	120
Green shale	240
DEVONIAN SYSTEM.	
Black shale	285
Cap rock	337
Pay	350
Whole	350

LOG No. 14.

Motley No. 4.

Strata	Feet
MISSISSIPPIAN SYSTEM	
Soil	19
Water	70
Sulphur	115
Casing	143
Green shale	255
DEVONIAN SYSTEM	
Black shale	310
Cap rock	359
Sand	350
Brake	395
Whole (Dry)	433

LOG No. 15.

Motley No. 5.

Strata	Feet
MISSISSIPPIAN SYSTEM	
Soil	18
Water	68
Sulphur	104
Cased	110
Green shale	260
DEVONIAN SYSTEM.	
Black shale	313
Cap rock	370
Pay	382
Whole	382

LOG No. 16.

Motley No. 6.

Strata	Feet
MISSISSIPPIAN SYSTEM	
Soil	14
Water	60
Sulphur	100
Cased	110
Green shale	252
DEVONIAN SYSTEM	
Black shale	302
Cap rock	353
Brake	360
Sand	370
Brake	383
Whole	383

LOG No. 17.

Finney No. 1.

Strata	Feet
MISSISSIPPIAN SYSTEM	
Soil	3
Water	40
Sulphur	70
Casing	140
Green shale	190
DEVONIAN SYSTEM.	
Black shale	214
Cap rock	275
Brake	281
Pay	287
Whole	300

LOG No. 18.

Finney No. 3.

Strata.	Feet
MISSISSIPPIAN SYSTEM.	
Earth	19
Water (no)	.....
Sulphur	100
Casing	120

LOG No. 19.

Finney No. 5.

Strata.	Feet
MISSISSIPPIAN SYSTEM.	
Soil	20
Water	40
Sulphur	80
Casing	110
Green shale	185
DEVONIAN SYSTEM.	
Black shale	210
Cap rock	260
Brake	272
Sand	284
Brake	-----
Sand	-----

LOG No. 20.

Finney No. 2.

Strata.	Feet
MISSISSIPPIAN SYSTEM.	
Soil	9
Water	30
Sulphur	90
Casing	120
Green shale	225
DEVONIAN SYSTEM	
Black shale	255
Cap rock	355
Pay	370
Whole	374

LOG No. 21.

Finney No. 4.

Strata	Feet
MISSISSIPPIAN SYSTEM	
Earth	18
Water	36
Sulphur	94
Casing	100
Green shale	225
DEVONIAN SYSTEM	
Black shale	250
Cap rock	352

LOG No. 22.

Finney No. 6.

Strata	Feet
MISSISSIPPIAN SYSTEM	
Soil	18
Water	38
Sulphur	75
Casing	105
Green shale	180
DEVONIAN SYSTEM	
Black shale	212
Cap rock	258
Brake	270
Sand	321
(Whole)	342

VARIOUS LOCATIONS IN WARREN COUNTY

LOG No. 23.

Hamilton No. 1.

(Just East of Bowling Green)

Strata	Thickness	Depth	
MISSISSIPPIAN SYSTEM			
Lime and shale	598	598	
DEVONIAN SYSTEM			
Black shale	77	675	
White lime	33	706	
Top of Sand	18	726	Pay sand
Bottom of Sand	23	749	Gray lime
Top of Sand	11	760	Pay & Oil
SILURIAN SYSTEM			
Blue lime	24	784	
Sand	8	792	Oil
Slate and shale	12	804	
Sand	8	812	Oil
Gray lime	18	830	Bottom

Authority of C. A. Phelps

LOG No. 24.

WELL AT BOWLING GREEN.

(From drillings.)

MISSISSIPPIAN SYSTEM.

White oolite.

Gray lime ..... at 18, 25 and 30
Light gray oolite ..... at 36
Fine-grained white lime ..... at 42 and 46 to 70
Light gray lime ..... at 77, 90, 94 and 98
White lime ..... at 100

Light brown lime ..... at 106
Light gray lime ..... at 112, 117, 130, 135, 144 and 156 to 170
Dark gray lime ..... at 183
Gray lime shale ..... at 189
Dark gray lime ..... at 195, 205 and 210 to 230
Black lime ..... at 235
Dark gray lime ..... at 240
Light brown lime ..... at 253
Gray lime ..... at 255 and 260
Dark lime ..... at 265
Brown lime ..... at 270
Dark gray lime ..... at 278 and 284
Brown lime ..... at 287
Gray lime ..... at 288, 290, 294, 300, 305, 310 and 315
Very dark lime ..... at 325 and 330
Gray lime—oil at 363 ..... at 340, 348, 350 and 358 to 380
Gray lime shale ..... at 400 to 420
Gray lime ..... at 425 and 430
Gray lime and shale ..... at 435, 440, 445 and 450
Gray and white limes ..... at 455
Gray lime and shale ..... at 460 and 465
Gray and white lime ..... at 470
Gray lime ..... at 475
Gray lime and white shale ..... at 485
Dark limy shale ..... at 490 to 501
Gray lime and limy shales ..... 506, 510 and 515
Gray limy shale ..... at 520 to 530
Dark lime and limy shales ..... at 535 to 665
Black slate ..... at 670 to 680
Very dark limy shale ..... at 685
Brown impure lime ..... at 690
Dark impure lime ..... at 695 and 700
Gray and white lime ..... at 705

DEVONIAN SYSTEM.

Black shale ..... at 708 to 760
Dark brown sandy lime ..... at 765 and 770
Mixed black, white and gray limes ..... at 775
Fine-grained white lime ..... at 780

SILURIAN SYSTEM.

Fine-grained yellowish lime ..... at 785 and 790
Fine-grained white lime ..... at 795 to 875
Gray lime ..... at 880 to 890
Very light lime ..... at 895 and 900
Gray lime ..... at 910
Light lime ..... at 915 to 935
Mottled red lime ..... at 940

ORDOVICIAN SYSTEM.

Gray lime ..... at 945 and 950
Light and gray limes ..... at 955, 960, 965, 975 and 980
Gray lime and shale ..... at 985
Mottled gray and white lime ..... at 990
Gray lime ..... at 995 to 1010 and 1015
Light lime ..... at 1020 and 1025
Gray lime and shale ..... at 1030 to 1095
Light and gray limes ..... at 1100 to 1185
White lime ..... at 1190
Gray limes ..... at 1195 to 1420
Dark limy shale ..... at 1425
Gray lime ..... at 1430 to 1440
Black and white limes ..... at 1445
Gray lime ..... at 1450 to 1460
Brown lime ..... at 1465
Gray lime ..... at 1470 to 1595
Light lime ..... at 1600 to 1605
Dark and light limes ..... at 1610 to 1660
Light dove-colored lime (top of Tyrone) ..... at 1660 to 1670
Gray and light limes ..... at 1685 to 1715
Very dark lime ..... at 1720 to 1730
Black lime ..... at 1735
Dark brown lime ..... at 1740 and 1745
Black lime ..... at 1750
Dark brown lime ..... at 1755
Gray lime ..... at 1760 and 1765
Very dark lime ..... at 1770
Gray lime ..... at 1775
Very dark lime ..... at 1780

LOG No. 25.

STAHL FARM.
West of Bowling Green.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Soil	4	4
White lime	211	215
Brown lime—black sulphur water at 295	85	300
White lime	150	450
Brown lime—"Blue Lick" water at 560	110	560
Lime	40	600
Blue shale	5	605
Hard lime	10	615
White lime	85	700
White shale	1	701

Brown lime	149	850
White lime	60	910
Blue lime	35	945
DEVONIAN SYSTEM.		
Black shale	110	1055
Brown lime	10	1065
SILURIAN SYSTEM.		
White lime	5	1070
Blue lime	25	1095
Cream-colored lime—oil	10	1105
Brown lime	6	1111
Cream-colored lime—oil	10	1121
Broken lime	19	1140
Very fine sand (lime?)	3	1143

LOG No. 26.

A. M. KIRBY WELL.
East of Alvaton.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Blue limestone	6	6
Flint	24	30
Gray limestone	15	45
Blue limestone	63	108
Yellow shale	8	116
Blue limestone	4	120
Gray limestone	30	150
Blue limestone	25	175
Gray limestone	49	224
Brown limestone	41	265
Lighter limestone	20	285
White limestone	35	320
Light gray limestone	15	335
White limestone	10	345
Blue limestone	35	400
DEVONIAN SYSTEM.		
Black shale	40	440
Blue lime	63	503
Lime sand	12	515
Blue limestone	10	525
Lime sand	15	540
Blue limestone	10	550
Lime sand	20	570
Blue limestone	15	580
Gas well.		

LOG No. 27.

LARMON WELL No. 1.
West of Alvation

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM		
Clay	25	25
Limestone	30	55
Lime shells	20	75
Slate	5	80
Soapstone	3	83
Limestone	20	103
Limestone	7	110
Sandy lime	5	115
Limestone	45	160
Lime shells	40	200
Sand shells	15	215
Brown lime	28	243
Sandy lime	12	255
Limestone	4	259
Shale	10	269
Limestone	14	283
Shale, sandy	45	328
Limestone	6	334
Shale, sandy	11	345
Limestone	11	356
Slate pencil	19	375
Lime, shelly	23	398
Slate	7	405
Sand shells	15	420
Slate	4	425
Limestone	45	470
Lime shells	5	475
Slate and shells	70	545
Limestone	12	557
Shale	6	563
Lime shell	1	564
DEVONIAN SYSTEM		
Shale	20	584
Shale	29	612
Limestone	4	616
Lime, sandy	20	636
Limestone	14	650
SILURIAN SYSTEM		
Limestone, sandy	5	655
Limestone	5	660
Limestone, sandy	5	665
Soapstone and sand	14	679

Limestone	4	683
Limestone	5	688
Limestone	4	692
Shale, sandy	32	724

LOG No. 28.

GARRISON FARM.
East of Bowling Green.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Soil	27	27
Lime	105	132
"Gas sand"	5	137
Lime	63	200
"Gas sand"	10	210
Lime	135	345
Green slate	37	382
Broken lime	8	390
DEVONIAN SYSTEM.		
Black shale	60	450
Brown lime	4	454
White lime	8	462
Brown lime—gas	28	490
SILURIAN SYSTEM.		
White lime	8	498
Brown lime	12	510
Gray lime	15	525
Brown lime—oil	12	537
Gray lime	45	582
Brown lime	8	590
Gray lime	10	600

LOG No. 29.

B. F. AMOS FARM.
Near Oakland.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Red clay	14	14
Lime	156	170
Sand	25	195
Lime	76	271
Slate	6	277
Lime	233	510
Slate	12	522
Lime	118	640

DEVONIAN SYSTEM.		
Brown shale	82	722
Lime	102	824
Sand—gas	24	848
Lime	177	1025
Red rock	44	1069
ORDOVICIAN SYSTEM.		
Lime	273	1342
Slate	116	1458
Lime	19	1477
Slate	6	1483
Lime	67	1550
Trenton*	59	1609

*Driller's distinction.

Top of Silurian passed by driller in 102 feet of lime below 722 feet.

LOG No. 30.

LUTHER JACKSON FARM.

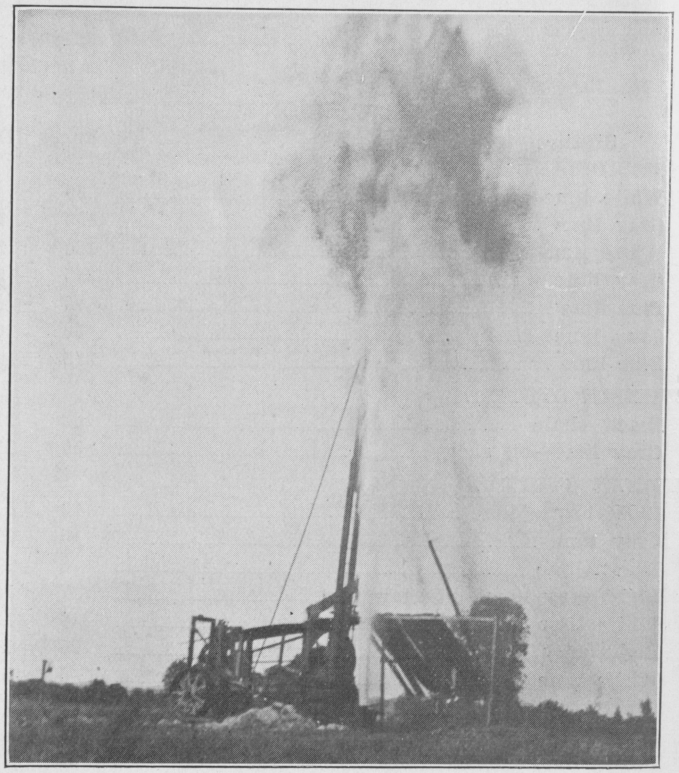
Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
White lime	35	35
Gray lime	105	140
White lime	120	260
Gray lime	315	575
Blue lime	90	665
Gray lime	30	695
Blue lime	315	1010
DEVONIAN SYSTEM.		
Black shale	102	1112
Gray lime—oil show	56	1168
SILURIAN SYSTEM.		
Light brown lime	10	1178
Gray lime	15	1193
Brown lime	8	1201
Light gray lime—oil show	7	1208
White lime	6	1214
Light gray lime	25	1239
White lime	5	1244
Light gray lime	28	1272
Gray lime	30	1302
Brown lime	33	1335
Gray lime with blue shale streaks	240	1575
Red rock	10	1585

ORDOVICIAN SYSTEM.

Soft broken lime	305	1890
Hard blue lime	98	1988
Brown sand	4	1992
Hard brown lime	5	1997
Dark blue shale	10	2007
Blue lime	31	2038

STRUCTURAL GEOLOGY

The general structure of Warren county is simple. The normal stratigraphic dip is to the northwest, the fall amounting to between thirty and thirty-five feet to the mile. This normal dip is broken by a series of flexures or folds, which sometimes show a reversal and closed



SHOOTING THE BOHON NO. 1
Photo by W. R. Jillson, August, 1919.

contour, and at other times simply a flattening to a definite terrace. The axes of these structures are generally northeast and southwest. For the most part the minor axis is short, giving a figure something in the shape of an overturned canoe. The number of closed or domed structures is relatively small. Due to the thick mantling of the red residual limestone soil which covers the principal part of the county, very few of the structures which must exist in Warren county can be seen at the surface. The widely distributed number of structures which have been found and mapped, however, stands as a strong indication of the fact that many others do exist and will be found later, in some cases by the drill. A number of the structures of Warren county have been plotted on the development map accompanying this report.

Oil and Gas Development

The principal area of development in Warren county to date, and the best in so far as development has produced the proof of production, lies in a belt running from the northeast to the southwest along the eastern boundary of the county. The belt includes the well known Moulder and Green Hill Oil Pools. It is an area pregnant with many possibilities, for some of the largest flush production which has ever been secured in Kentucky came during the present year from the Moulder Pool. The depths along this belt vary from 400 feet to 550 feet to the Onondaga (Corniferous) Limestone, which is the productive horizon. Altogether about three hundred wells have been drilled in this section and the larger number of these have shown production of commercial importance. West of the Green Hill Oil Pool along Drakes Creek a number of gas wells were drilled in some years ago, but are not of particular importance. In and about Bowling Green a number of wells have been drilled, most of which have secured oil from the Warsaw-Fort Payne horizons, of the Mississippian. A few have brought in production from the Onondaga (Corniferous), of the Devonian. Due west of Bowling Green adjoining the Morgantown Pike and Gaspers River, there is some old development and production in what is known as the Jackson Pool. North-

west of Bowling Green on the Rayes Valley Pike, near Richardsville, a number of wells have been drilled to the Onondaga (Corniferous), with varying results. Some production and some salt water has been secured. West and northwest of Bowling Green, about four miles, several wells have been drilled in recently to oil and gas production in the Onondaga (Corniferous) Limestone, which suggest productive possibilities for this section. Of chief present interest in this section are the new and promising Hunter and Davenport wells. Very little development has gone forward in northern Warren county in the Sand Hill and Plum Spring sections, or in southwestern Warren county, near Rockfield and Woodburn. The most promising area in Warren county for development purposes is the belt along the Allen-Barren line, where the Green Hill and Moulder Pools have been developed. To the practical man this area is important, because of the shallow drilling depths and a generally porous condition found in the Onondaga (Corniferous) Limestone. In comparison to this area the remainder of Warren county excepting the district about Thomas' Landing is at present much less attractive, though not without immense possibilities. A large number of scattered wells, however, show the sands under the western area to be not only deep, but tight, two considerations which militate against successful drilling.

Established and Operating Pipe Lines

The Green Hill Pool is served by the Bowling Green Pipe Line, four inches, replacing the old two inch line of the American Pipe Line Company. The Moulder Pool is served by the Swiss Pipe Line, four inches, and by the Butler Pipe Line, four inches, both of which find their terminus and loading rack at Smiths Grove.